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ABSTRACT

This document contains supplemental materials for special needs high school students intended to facilitate their mainstreaming in regular air conditioning and refrigeration courses. Teacher's materials precede the materials for students and include general notes for the instructor, additional suggestions, two references, a questionnaire on the usefulness of the supplemental materials, a class progress chart, and an answer key to student worksheets. The student materials consist of 11 color-coded instructional units on the following topics: safety; current, voltage, and resistance; relays and contactors; electric motors; electrical components; diagnosing compressor problems; troubleshooting mechanical problems in domestic refrigeration system (two units); air conditiong systems; charging units; and commercial refrigeration units--preventive maintenance. The units are self-paced and contain simplified line drawings, controlled text, vocabulary development, and math practice exercises. The units typically include the following materials: (1) an introduction; (2) the objective of the unit; (3) the objectives on which students will be assessed; (4) terms and pictures of equipment used in the unit and on the job; (5) verbal and illustrated step-by-step explanations of a skill or task; (6) skill sheets that contain paper and pencil exercises to develop and reinforce math skills; (7) activity sheets designed to increase student involvement and provide extra skill practice; (8) unit reviews involving identification, matching, multiple-choice, and short-answer exercises; and (9) checklists on which to evaluate student performance. (CML)

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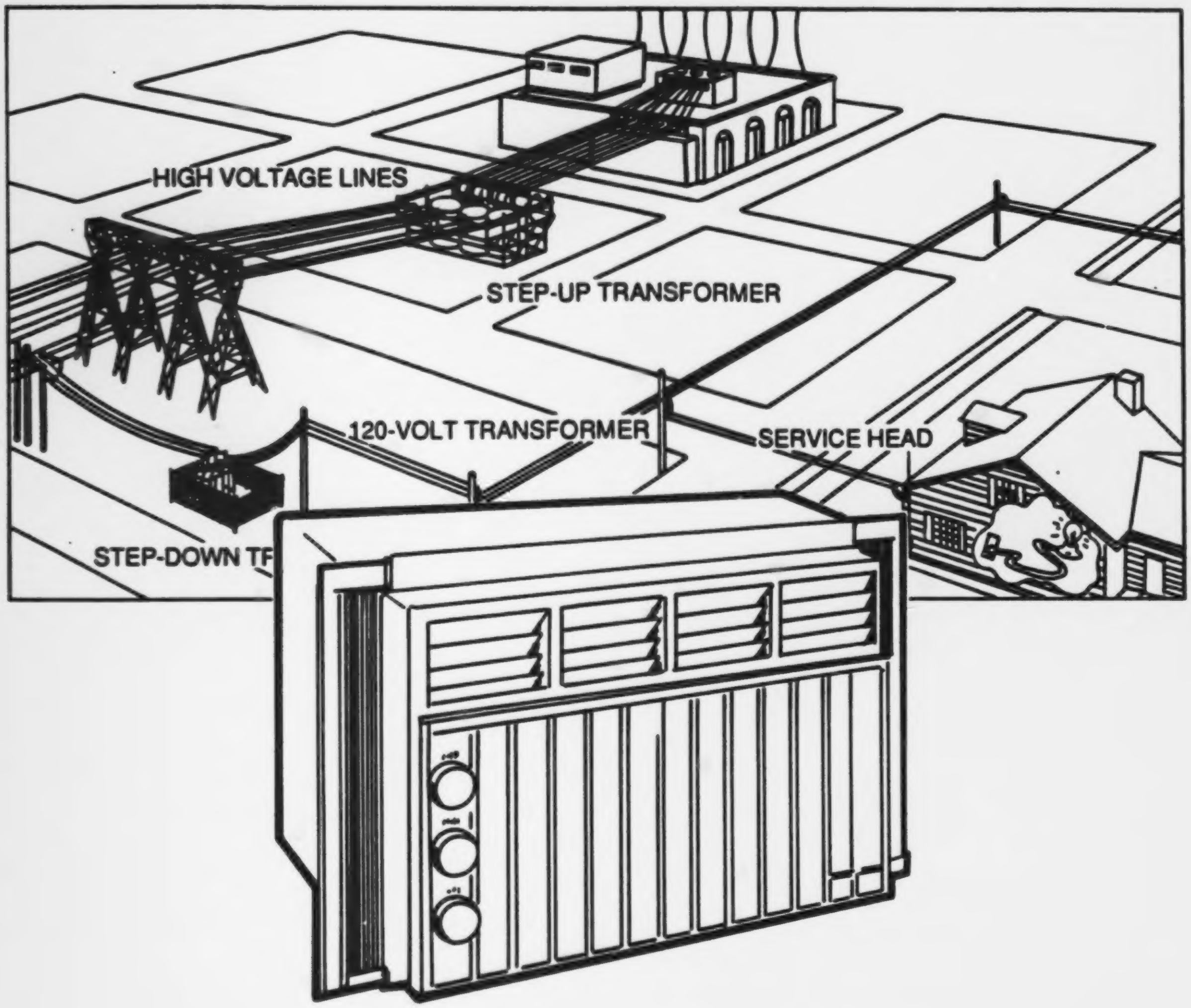
SUPPLEMENTARY UNITS FOR



Air Conditioning and Refrigeration

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Air Conditioning and Refrigeration

Supplementary Units

by
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University of Missouri - Columbia
Columbia, Missouri

Catalog Number 90-7040-S

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Preface

Air Conditioning and Refrigeration Supplementary Units are a Special Needs curriculum project sponsored by the Missouri Department of Elementary and Secondary Education. The purpose of this project is to provide supplementary materials for special needs students who are enrolled in regular Air Conditioning and Refrigeration courses.

The special needs units should facilitate the mainstreaming of students with handicapping or disadvantaged conditions. The units are self-paced and contain simplified line drawings, descriptive text, vocabulary development, and math practice exercises. Units are color-coded as follows:

White: Introduction, Objectives, and Student Assessment - This page presents unit and specific objectives which the student must meet to successfully complete the unit. The introduction contains a brief motivational statement describing the purpose and content of the unit. Student Assessment allows the student to determine whether to study the material in the unit or take the unit exam.

Salmon: Terms and Equipment - This section introduces new terms and equipment necessary for the student to understand and perform the tasks shown in the unit.

Canary: Steps of Procedure - This presents a verbal and illustrated step-by-step expla nation of a given skill or task.

Green: Skill Sheets - These pages provide paper and pencil exercises to develop and reinforce concepts and skills necessary to perform the procedures in the unit.

Blue: Activity Sheets - Various activities are presented to increase student involvement and provide extra practice in performing the procedures.

Pink: Unit Review and Performance Checklist - These sheets are used by the instructor to evaluate student performance. Different forms of review, including identification, matching, multiple-choice, and short answer exercises are provided.

Instructor's information, located in the front of the book, contains notes to the instructor, bibliography, and answer keys.

Acknowledgements

These supplementary units are the outcome of efforts by the following individuals:

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General Notes to the Instructor

Step 1: Read through the information in each unit before presenting it to the student (Note: Carefully evaluate the content of each unit and any safety considerations regarding the Steps of Procedure and activities to determine appropriateness for the student.)

Step 2: Make sure all equipment to be used in each unit is available.

Step 3: Prepare any handouts, visuals, or supplemental material to aid student learning activities.

Step 4: Provide student with Introduction page.

Step 5: Discuss tasks on Introduction page and give directions for completing the Are You Ready section.

Step 6: Have student complete Introduction page.

Step 7: If student elects to complete the Unit Review and Performance Checklist and does so to your satisfaction, have student proceed to the next unit. If student does not wish to do the exercises, proceed to the next step.

Step 8: Discuss the Introduction page information with the student. At this time you can also discuss the Terms and Equipment lists.

Step 9: Provide student with Steps of Procedure section.

Step 10: Select a means to present the Steps of Procedure. (This will depend upon the capabilities of the student.)

Step 11: Instructor can demonstrate procedures to the student or class.

Step 12: Allow student time to learn the procedure. Individual judgement by the instructor will determine proper amount of time.

Step 13: Have student complete all Skill Sheets for the unit. Skill Sheets reinforce skills necessary to perform the procedures in the unit and may also be used as self-evaluation by the student and as points of discussion by the class.

Step 14: Complete any applicable activities listed on the Activity Sheets.

Step 15: When student is ready, use the Unit Review and Performance Checklist to evaluate student's performance for that unit.

Additional Suggestions

- Try a team approach when possible or have students work in pairs.

- Review equipment with students whenever necessary.

- Review safety precautions whenever appropriate.

- Exercises can be used as a pencil and paper exercise or in any way instructor feels will help to clarify the material.

- Additional modifications can be made to take care of other disadvantaged/handicapped conditions unique to the situation.

References

Mid-America Vocational Curriculum Consortium. *Air Conditioning and Refrigeration*, Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1984.

Althouse, Andrew D., Carl H. Turnquist, and Alfred F. Bracciano. *Modern Refrigeration and Air Conditioning,* South Holland, IL.: Goodheart-Willcox Company, Inc. 1979.

IMPORTANT NOTICE FOR THE INSTRUCTOR

Before introducing material in each unit to the classroom, the instructor is reminded to carefully consider and adopt all safety precautions that might be indicated by the activities described in each unit and to avoid all potential hazards. By following the instructions within each unit, the instructor and student willingly assume all risks in connection with instructions

Questionnaire

Staff members, writers and advisors have worked to make these instructional materials easy to use and easy to read. We welcome your suggestions or corrections. Please return this questionnaire with your comments to:

Special Needs Editor
Instructional Materials Laboratory
10 London Hall
University of Missouri-Columbia
Columbia, Missouri 65211

Thank you for your time and consideration.

Air Conditioning and Refrigeration Supplementary Units

Circle your overall rating of the publication:

Excellent Very Good Good Fair Poor

I would suggest that to improve the materials, IML should:

____

____

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Other Comments:

____

____

____

____

OPTIONAL

Name: ____________________________________

Address: __________________________________

____

SAFETY

SKILL SHEET 1

Directions: Put a mark beside each statement that tells a practice you currently use in your laboratory setting. Afterwards, circle the numbers of the statements that are examples of safety practices you should follow in the lab.

YES	NO		DO YOU:
		1.	Work only in assigned areas?
		2.	Always wear approved eye protection?
		3.	Understand all rules applying to each piece of equipment before startup?
		4.	Put all tools in their proper place?
		5.	Pay attention while operating equipment?
		6.	Retain all guards and safety devices?
		7.	Always wear rubber gloves when working on high voltage?
		8.	Wipe up spills immediately?
		9.	Report defective equipment?
		10.	Keep floors free of dirt, scraps, and parts?
		11.	Keep work areas clean and orderly?
		12.	Wear safe work shoes?
		13.	Know where the fire extinguishers are located?
		14.	Know how to use fire extinguishers?
		15.	Know the location of the first aid kit?
		16.	Read warning labels on equipment?
		17.	Lock off or tag switches controlling high voltage when the circuit is being worked on?
		18.	Know what steps to take in case of accident and injury?

Answers will vary according to student.

SAFETY

UNIT REVIEW

Directions: Put an "x' in front of each correct statement about shop safety.

X 1. Accidents can happen when there are practical jokes and horseplay in the shop.
X 2. Accidents can happen in any area of the shop you work in.
X 3. Approved eye protection should always be worn.
X 4. Never turn an appliance on while standing in water.
X 5. All tools should be kept sharp and clean.
X 6. Fire safety must be practiced everywhere in a shop.

Directions: Circle the best word(s) in each sentence to make a safety rule.

7. Only work with refrigerants in a well (shaded, [✓ ventilated]) area.

8. If you spill something, (walk around it, [✓ wipe it up]).

9. Apply ([✓ pressure], warmth) to a cut to help stop bleeding.

10. Store oily rags in a ([✓ closed metal container], cardboard box).

11. When working with electricity, use tools that have ([✓ insulated], rough) handles.

12. If you drop something pick it up ([✓ right away], later).

Directions: Circle the letter of the correct answer for each statement below. Statements may have more than one correct answer.

13. When working on high voltage, wear:
    a. Leather shirt
    [✓ b.] Rubber gloves
    c. Goggles

14. Good safety rules for refrigerants are:
    [✓ a.] Wear safety glasses.
    [✓ b.] Never use an open flame to heat up a refrigerant tank.
    c. Don't worry about warning labels.

Directions: Match the color to its safety meaning.

b 1.	Red	a.	Safety and first aid equipment
e 2.	Orange	b.	Location of firefighting equipment and emergency switches for machinery
d 3.	Yellow	c.	Radiation hazards
a 4.	Green	d.	Caution, physical hazards
c 5.	Purple	e.	Dangerous parts of machines

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CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 2: MEASURE VOLTAGE

Directions: Follow the steps below to measure voltage.

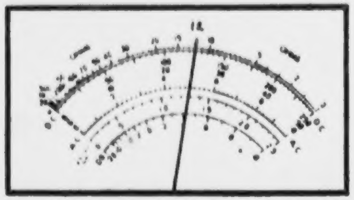
1. Ask your instructor to watch you do this procedure.
2. Set up the meter to measure voltage as shown in the steps of procedure.
3. Measure the voltage at a wall outlet.
4. Record your reading: ________________ volts

Answers will vary according to student.

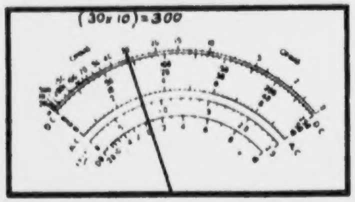
CURRENT, VOLTAGE, AND RESISTANCE
SKILL SHEET 2: READING OHMS ON SELECTOR-SWITCH MULTIMETER

Directions: Use a straight edge to draw in the pointer to show the following:

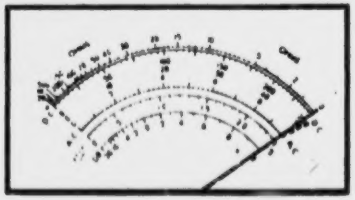
1. A reading of 12 ohms when range switch is at RX1.



2. A reading of 300 ohms when range switch is at RX10.



3. Show a short circuit reading.

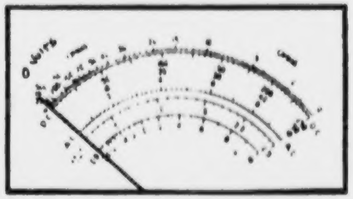


CURRENT, VOLTAGE, AND RESISTANCE
SKILL SHEET 1:
READING VOLTAGE ON A SELECTOR-SWITCH MULTIMETER

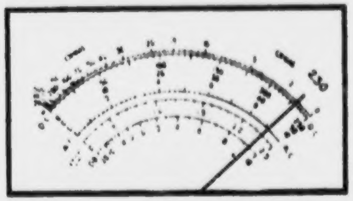
Directions: Use a straight edge to draw in the pointer to show the following:

CAUTION:THIS IS A PAPER-AND-PENCIL ACTIVITY. DO NOT ACTUALLY ATTEMPT TO TAKE THESE READINGS.

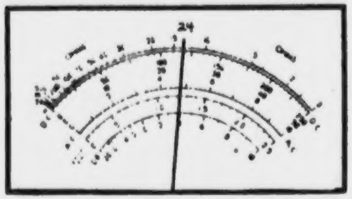
1. An open circuit reading.



2. 230 volts when the range switch is at 250 ACV.



3. 24 volts when the range switch is at 50 VAC.



CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 1: MEASURE CURRENT

Directions: Follow the steps below to measure current.

1. Ask your instructor to watch you do this procedure.
2. Plug a lamp into the end of a line splitter. Then plug the line splitter into a wall outlet.
3. Turn on the lamp with a 100 watt bulb.
4. Measure current as shown in the steps of procedure.
5. Record you reading: ______________ amps
6. Repeat above steps with a 25 watt bulb in the lamp.
7. Record your reading: ______________ amps

Answers will vary according to student.

CURRENT, VOLTAGE, AND RESISTANCE

UNIT REVIEW

Directions: For each of the following questions, circle the best answer.

1. Electricity moving through a wire is called: d.

   a. Power
   b. Voltage
   c. Resistance
   [✓ d.] Current

2. Electrical pressure that pushes the electricity through the wire is called: b.

   a. Power
   [✓ b.] Voltage
   c. Resistance
   d. Current

3. The opposition to current flow is called: c.

   a. Power
   b. Voltage
   [✓ c.] Resistance
   d. Current

4. The amount of current is measured in:

   [✓ a.] Amps
   b. Volts
   c. Ohms
   d. Pounds

5. The amount of resistance is measured in:

   a. Amps
   b. Volts
   [✓ c.] Ohms
   d. Pounds

6. When measuring resistance, the power must be turned on.

   True or [✓ False]

7. When checking a circuit for continuity, the power must be turned off.

   [✓ True] or False

8. A short circuit has very little or no resistance.

   [✓ True] or False

9. A clamp-on type meter only works with alternating current.

   [✓ True] or False

10. An open circuit is shown by a reading of zero (0) on the ohms scale.

   True or [✓ False]

ANSWER KEY

CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 3: USE AN OHMMETER

Directions: Follow the steps below to use an ohmmeter.

1. Ask your instructor to watch you do this procedure.
2. Set up the meter to measure resistance as shown in the steps of procedure.
3. Measure the resistance of the 25 watt light bulb.
   Record your answer:________ ohms.
4. Measure the resistance of the 100 watt light bulb.
   Record your answer:________ ohms.
5. Check the two fuses for continuity as shown in the steps of procedure.

	Open	Short	Good	Bad
Fuse #1				
Fuse #2				

Answers will vary according to student.

CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 4: DEMONSTRATE KNOWLEDGE OF METERS

Directions: Follow the steps below to demonstrate your knowledge and understanding of meters.

1. Get one rotary scale clamp-on type meter and one line splitter.
2. Show them to your instructor. Name each part and tell what it does. Explain how to use the meter.
3. Get one selector switch multimeter.
4. Show it to your instructor. Name each part and tell what it is used for. Explain how to use the meter.

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RELAYS AND CONTACTORS
ACTIVITY SHEET 1

1. Use an ohmmeter to check a current relay.

   a) With the relay right side up reading from "M" to "1" is _______________ ohms.

   b) Reading from "S" to "1" is _________ ohms.

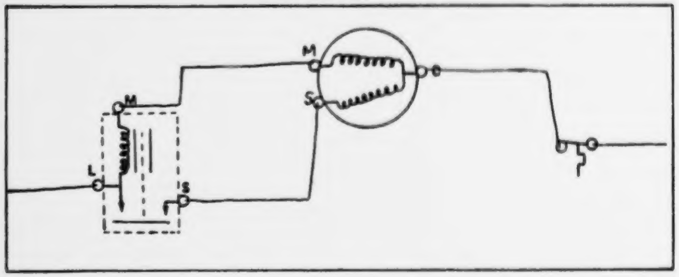
   c) With the relay upside down reading from "S" to "1" is _______________ ohms.

   If you shake the relay, can you hear a rattle?

   YES ___ NO ___

   This relay is good ___ bad ___

2. Draw the electrical connection for a current relay.



RELAYS AND CONTACTORS

ACTIVITY SHEET 2

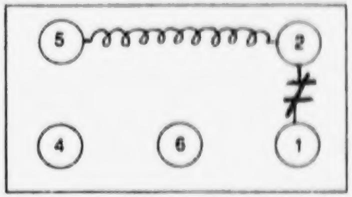
1. Use an ohmmeter to check a potential relay.

   Reading from 1 to 5 is _________ ohms.

   This relay is ___ unknown
   ___ good
   ___ bad

2. How could you tell if contacts between 1 and 2 are stuck or welded shut?
   A- using an ammeter between 1 & capacitor to see if amperage drops to 0 when unit starts
   B- using a voltmeter with probes on 1+2, see if you get a voltage reading when unit starts.

3. Draw the electrical connections for the potential relay shown below.



ANSWER KEY

RELAYS AND CONTACTORS

ACTIVITY SHEET 3

Check a control relay with an ohmmeter and answer the following questions.

1. What is the resistance of the coil? ________ ohms

2. How many normally open contacts does this relay have?

   ____

3. How many normally closed contacts does this relay have?

   ____

4. Draw a picture showing the electrical connections in this relay.

Answers will vary according to student.

XIX

RELAYS AND CONTACTORS

UNIT REVIEW

1. A current relay has contacts that are

   [✓ a)] N.O.
   b) N.C.
   c) Mixed
   d) Fixed

2. A potential relay has contacts that are

   a) N.O.
   [✓ b)] N.C.
   c) Mixed
   d) Fixed

3. A relay is an electrically operated

   a) Pole
   b) Control
   [✓ c)] Switch
   d) Transformer

4. A contactor is a large

   [✓ a)] Relay
   b) Transformer
   c) Control
   d) Load

5. In a relay each path of current through the contacts is called a

   a) Load
   b) Control
   c) Transformer
   [✓ d)] Pole

6. The coil of a current relay has low resistance.
   [✓ True] or False

7. The coil of a potential relay has low resistance.
   True or [✓ False]

8. Solid state relays are commonly used to replace current relays.
   [✓ True] or False

9. A type of relay used to start larger hermetic motors is a
   potential relay.

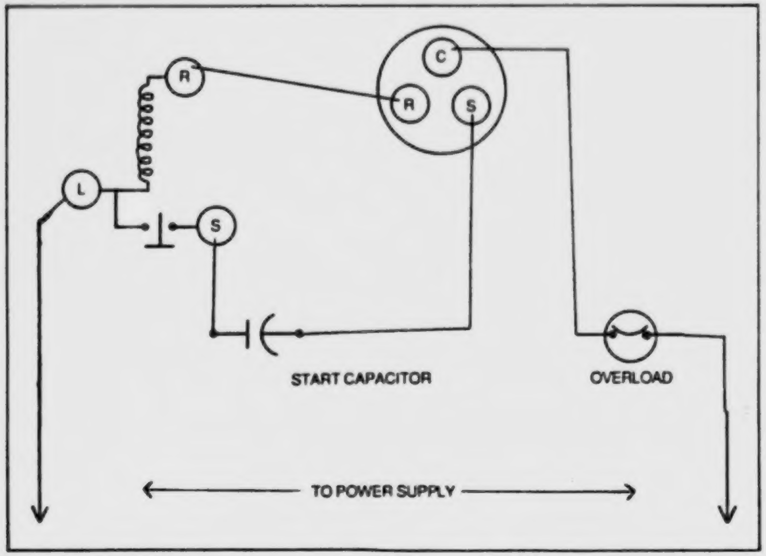
10. A type of relay used to start smaller hermetic motors is a
    current relay.

ANSWER KEY

ELECTRIC MOTORS

SKILL SHEET 1 - ELECTRICAL CONNECTIONS

Directions: Draw in the Electrical Connections.

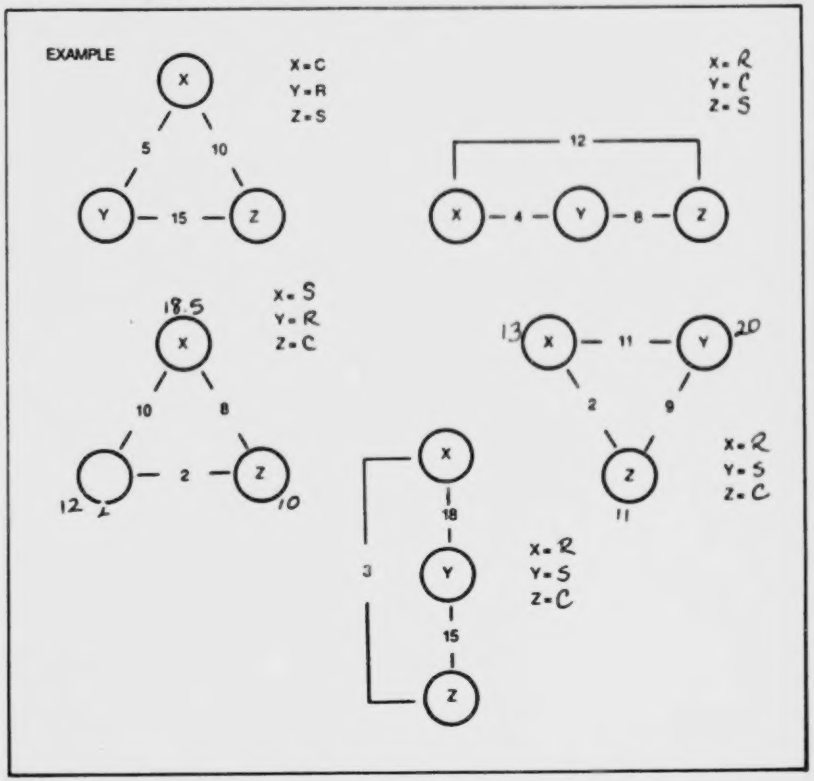

R
C
R
S
L
S
START CAPACITOR
OVERLOAD
TO POWER SUPPLY

ELECTRIC MOTORS

SKILL SHEET 2

IDENTIFYING HERMETIC MOTOR TERMINALS

Directions: Identify the hermetic motor terminals.


EXAMPLE
X
Y
Z
5
10
15
X=C
Y=R
Z=S
X= R
Y= C
Z= S
12
X
4
Y
8
Z
18.5
X
Y
Z
10
8
2
12
10
X= S
Y= R
Z= C
13
X
11
Y
20
2
9
Z
11
X= R
Y= S
Z= C
X
18
Y
15
Z
3
X= R
Y= S
Z= C

XX

XXI

ELECTRIC MOTORS

UNIT REVIEW

Directions: Circle the letter of the best answer.

1. Are hermetic motors used to turn fans and blowers?
   - a) Yes
   - [✓ b) No]

2. If a small evaporator fan motor does not work, it should be:
   - [✓ a) Replaced with a new one]
   - b) Repaired
   - c) Cleaned, oiled, and tested.

3. Do all hermetic motors have run, start, and common terminals connected to the motor windings?
   - [✓ a) Yes]
   - b) No

4. Do all hermetic motors use start relays?
   - a) Yes
   - [✓ b) No]

5. What type of hermetic motor is commonly used in window air conditioners?
   - [✓ a) PSC]
   - b) SCIR
   - c) Split phase
   - d) Shaded poles

6. What should be done when removing end bells from a motor?
   - a) Mark the frame.
   - b) Mark the end bells.
   - [✓ c) All of the above]
   - d) None of the above

7. You can change bearings on:
   - [✓ a) Open motors]
   - b) Hermetic motors
   - c) All of the above
   - d) None of the above

8. A motor that runs on a test cord, but not when it is installed in a refrigeration system:
   - a) Is bad
   - b) Should be replaced
   - c) All of the above
   - [✓ d) None of the above]

9. May current - type start relays safely be installed upside down?
   - a) Yes
   - [✓ b) No]

10. An identified terminal of a run capacitor must be connected to the leads that go to the Run.

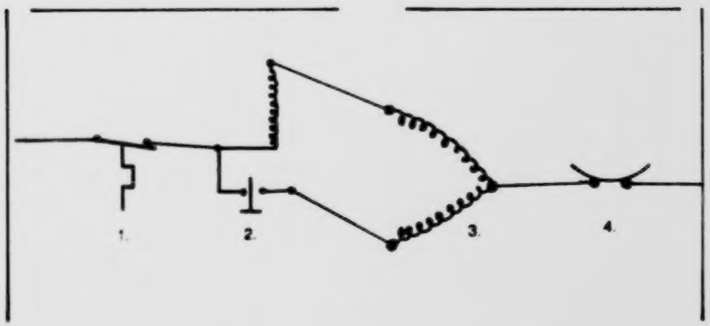
ANSWER KEY

ELECTRICAL COMPONENTS

SKILL SHEET 1

Directions: Study the following schematics and follow the instructions to complete each activity.

(NOTE: This activity may be used if wiring diagrams has been taught.)



A. Connect the components in this ladder schematic so that the system would run.

B. List the names of the numbered components.

1. Thermostat
2. Relay
3. Compressor
4. Overload

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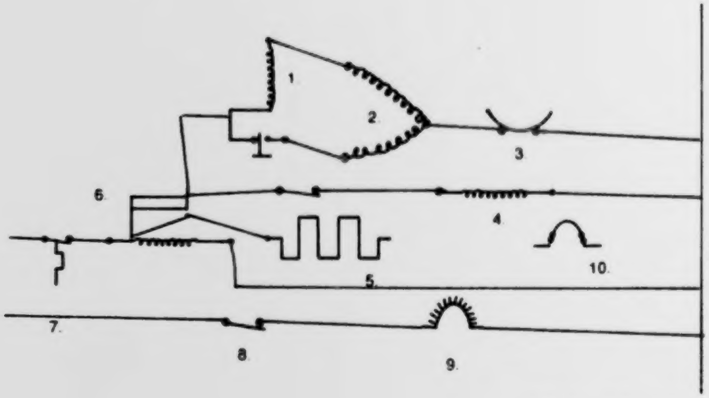


Compressor
Current Relay
Overload
Defrost Timer
Defrost Heater
Fan Switch
Light Switch
Fan Motor
Thermostat
Light
Defrost Termination Thermostat

A. Connect the above components so the system will run properly.

B. Name the numbered components. Use the list above.

1. current relay
2. compressor
3. overload
4. fan motor
5. defrost heater
6. defrost timer
7. thermostat
8. light switch
9. light
10. defrost termination thermostat

34

XXiii

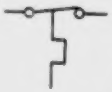
ELECTRICAL COMPONENTS

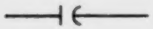
SKILL SHEET 2

Directions: Write the letter for each component in the blank beside its name.

M 1. compressor motor terminal
G 2. defrost timer
D 3. defrost heater
A 4. thermostat
L 5. circuit breaker
B 6. start relay
C 7. start capacitor
E 8. defrost termination thermostat
F 9. overload protector
J 10. switch
I 11. light
H 12. transformer
K 13. fuse

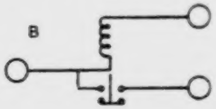
A

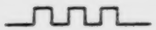




C

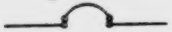
B





D

E



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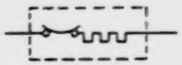

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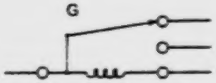

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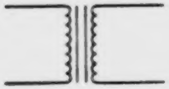
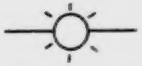
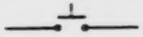


I



J



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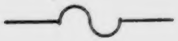

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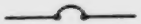
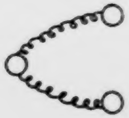


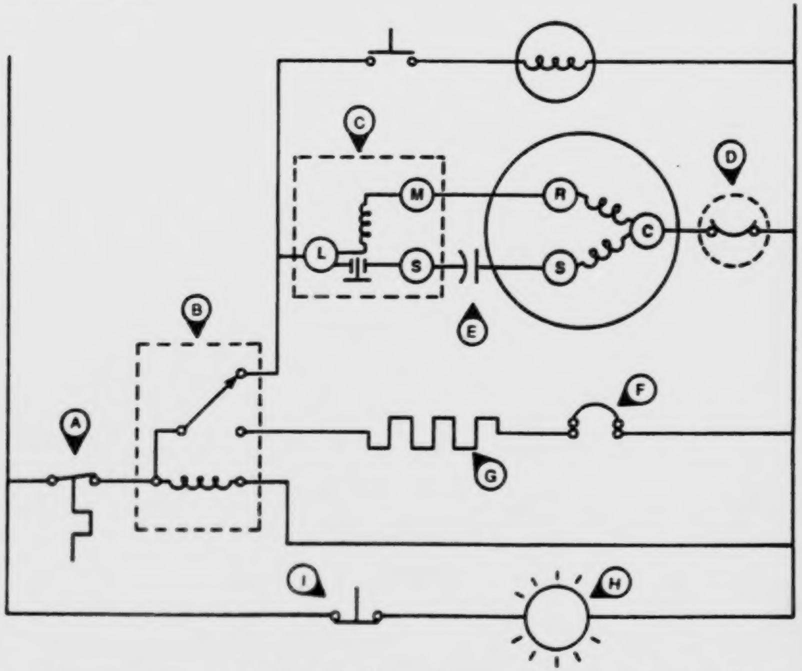
M



ELECTRICAL COMPONENTS

SKILL SHEET 3

Directions: Write the name of each symbol for the air conditioning components on this diagram.



A Thermostat B Defrost Timer C Current Relay D Overload

E Start Capacitor F Defrost Term. Therm. G Defrost Heater H Light

I Light Switch

ANSWER KEY

ELECTRICAL COMPONENTS

UNIT REVIEW

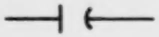
Directions: Read the following statements and choose the correct answer for each by circling the correct answer.

1. An electrical switch that is operated by a change in temperature is called a:

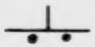
A. Transformer
B. Timer
[✓ C.] Thermostat
D. Start Relay

2. A start relay is used to disconnect the power to the:

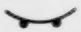
[✓ A.] Start Winding
B. Common Terminal
C. Run Winding
D. Protector

3.  This is the symbol for:

[✓ A.] Capacitor
B. Start Relay
C. Push Button Switch
D. Overload Protector

4.  This is the symbol for:

A. Capacitor
B. Start Relay
[✓ C.] Push Button Switch
D. Overload Protector

5.  This can be used as a symbol for:

A. Capacitor
C. Start Relay
B. Push Button Switch
[✓ D.] Overload Protector

6. The overload protector turns off the compressor if it becomes too:

A. Cold
[✓ B.] Hot
C. Crowded
D. Fast

7. What component turns off a start capacitor?

A. Thermostat
[✓ B.] Start Relay
C. Defrost Timer
D. Overload Protector

8. A component that melts the frost which builds up on the evaporator in a refrigerator is a:

A. Fuse
B. Terminal
C. Run Capacitor
[✓ D.] Defrost Heater

9. Compressor motor terminals connect the motor with the:

A. Electricity
[✓ B.] Start Relay
C. Light
D. Overload Protector

10. A component used to turn off the electricity in an overload or short circuit is a:

A. Transformer
B. Compressor
C. Evaporator
[✓ D.] Fuse

11. A component which can be reset after an overload has occurred is a:

A. Transformer
[✓ B.] Circuit Breaker
C. Fuse
D. Capacitor

12. A component used to turn a light or fan on and off is called a:

[✓ A.] Switch
B. Fuse
C. Transformer
D. Start Relay

DIAGNOSING COMPRESSOR PROBLEMS

ANSWER KEY

SKILL SHEET 1

1. ammeter
2. pinch-off tool
3. refrigeration gauge set
4. stem-type service valve

UNIT REVIEW

1. Clockwise
2. Counter clockwise
3. Full Load Amperage or FLA
4. a. Above normal temperature in the freezer
    b. Above normal temperature in the fresh food compartment
    c. Fully frosted evaporator
    d. Below normal FLA
    e. Noisy compressor
5. Pinch-off tool
6. 25 or 30
7. d, e, g, b, a, h, f, c

TROUBLESHOOTING MECHANICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

ANSWER KEY

SKILL SHEET 1

1. 35.7 PSI
2. 92.9 PSI
3. 19.8 PSI
4. 31.2 PSI
5. 19.0 PSI

UNIT REVIEW

1. FALSE
2. TRUE
3. D
4. D
5. D
6. TRUE
7. A
8. B
9. TRUE

AIR CONDITIONING SYSTEMS

ANSWER KEY

SKILL SHEET 1

1. Turn the thermostat to maximum cool position.
2. Turn the window unit on to the low cool position.
3. Carefully observe the suction line for sweating and frost.
4. Restrict the air flow and watch the low side for frost at the level of refrigerant.
5. Watch for frost to appear on the suction line.

UNIT REVIEW

1. FALSE
2. FALSE
3. TRUE
4. TRUE
5. FALSE
6. d
7. FALSE
8. a
9. FALSE

TROUBLESHOOTING ELECTRICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

ANSWER KEY

SKILL SHEET 1

(The answers can be in any order.)

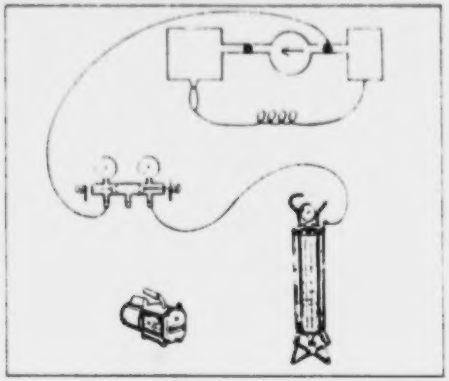
1. compressor
2. condenser fan motor
3. evaporator fan motor
4. defrost heaters
5. defrost control motor
6. heaters (three)
7. light

UNIT REVIEW

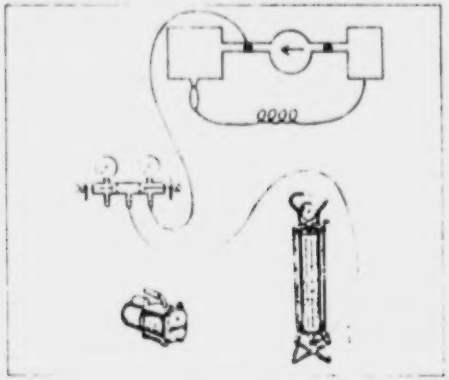
1. TRUE
2. FALSE
3. FALSE
4. TRUE
5. TRUE
6. b
7. d
8. b
9. TRUE

CHARGING UNITS

ACTIVITY SHEET 1 - ANSWER KEY

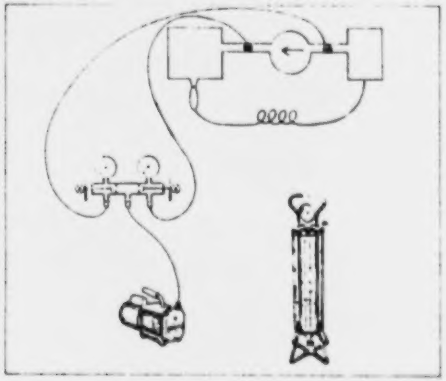


ACTIVITY SHEET 2 - ANSWER KEY



CHARGING UNITS

ACTIVITY SHEET 3 - ANSWER KEY



UNIT REVIEW

ANSWER KEY

1. True
2. b
3. c
4. a
5. c
6. d
7. c
8. True
9. False
10. b

COMMERCIAL REFRIGERATION UNITS– PREVENTIVE MAINTENANCE

ANSWERS

ACTIVITY SHEET 1

The answers should mention the following critical areas:

1. Condensers:
   clean, fins straight, visually checked for leaks
2. Fan motor:
   cleaned of dirt and dust, oiled, bearings checked for roughness
3. Belts:
   tension checked, fraying, pully alignment
4. Blades:
   bent, cracked and cleaned
5. System refrigerant leaks:
   oil on lines, oily dust on lines, check joints, elbows, bends and flares for suspected leaks (use leak detector to double check suspicious areas)

SKILL SHEET 1

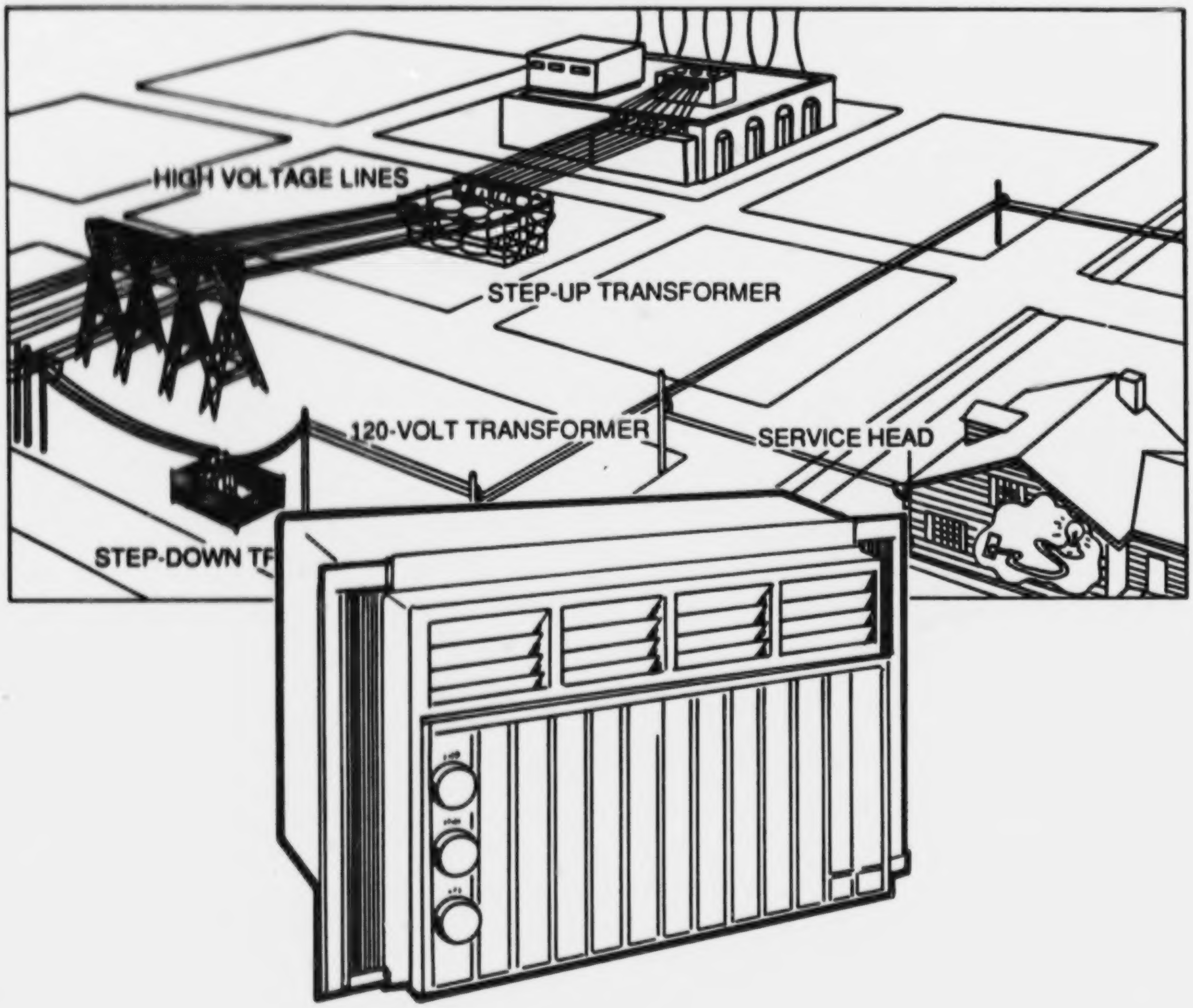
1. power or hand sprayer
2. flashlight
3. liquid leak detector
4. danger tag
5. fin comb
6. inspection mirror
7. air hose and blow gun
8. shop vacuum
9. coil cleaning fluid
10. portable air compressor or portable compressed air tank

UNIT REVIEW

1. False
2. D
3. True
4. A
5. True
6. True
7. False
8. False
9. B
10. False

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 1

Safety

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

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SAFETY

INTRODUCTION

Each year thousands of workers are injured in accidents. Everyone loses when there is an accident. Millions of dollars are lost each year in industries as a result of lost worker time, medical expenses, equipment down time and repairs. In addition, families are affected when a loved one is killed or injured. Income stops, medical bills rise, and the worker as well as his/her family are under stress. Fortunately, most accidents can be avoided by using safe techniques and procedures when working with hazardous materials and equipment.

Workers in the field of Air Conditioning and Refrigeration face many hazards in everyday work. Safe work habits result from a knowledge of these hazards and what safety precautions to take. Each person has a responsibility to him/herself and coworkers to work safely and avoid accidents.

UNIT OBJECTIVE

After completing this unit, you should be able to identify safety hazards in the shop and avoid or correct hazards.

SPECIFIC OBJECTIVES

After completion of this unit, you should be able to specifically:

1. Demonstrate general shop safety procedures.
2. Use appropriate protective clothing.
3. Demonstrate safe procedures for working with electrical equipment.
4. Demonstrate safe procedures for handling refrigerants.
5. Show how to use first aid procedures.
6. Demonstrate proper fire safety procedures.
7. Match safety colors to their meanings.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

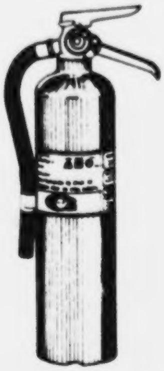
A. Terms and Equipment

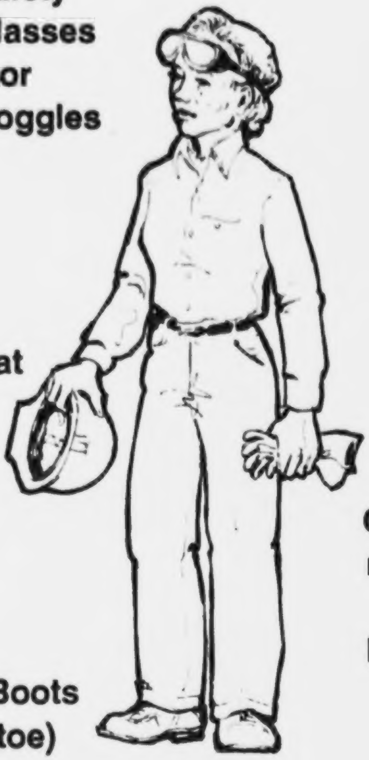
Terms

1. Antiseptic - something that prevents infection by killing germs.
2. Combustible - something that will easily catch fire and burn.
3. Conductive - able to carry electricity.
4. Flammable - something that is quick to catch on fire.
5. First aid - immediate treatment given for injuries such as falls, cuts, or burns.
6. Hazard - a dangerous condition which can cause an accident.
7. Nonconductive - not able to carry electricity.
8. Prevention - stopping or keeping something from happening.
9. Procedure - a way of doing something.
10. Safety - conditions that are free of dangers.
11. Safety guards - devices used on hazardous equipment to protect the worker from injury.
12. Ventilated - having fresh air move through an area.

Equipment

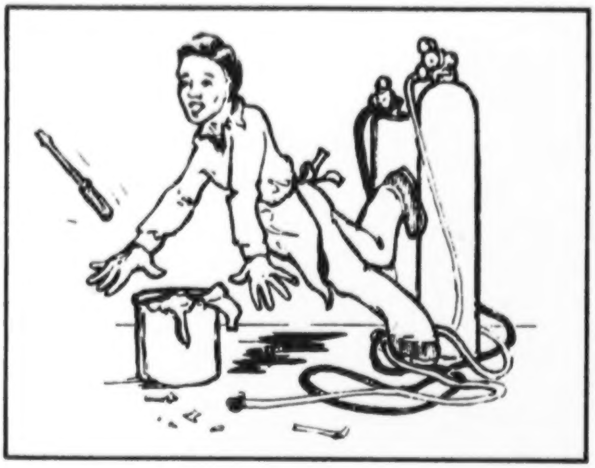
Fire Extinguisher



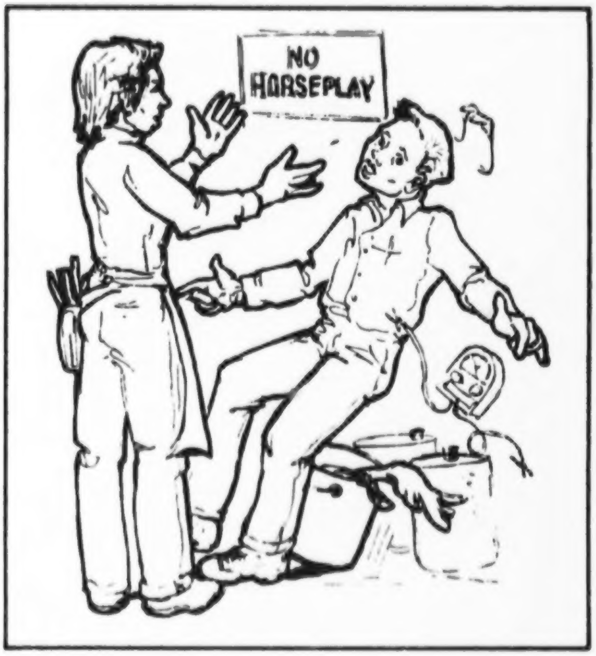

Safety Glasses or Goggles
Hard Hat
Gloves rubber or leather
Work Boots (Steel toe)

B. General Shop Safety Procedures

1. Keep your shop clean.
    - Store oily rags in a closed metal container.
    - Clean up spills as soon as they occur. Never use gasoline to clean up tools, parts, or oil spills.
    - Clean all work areas of dirt, scraps, and parts.
    - Do not leave drop cords, hoses, or parts on the floor. (Someone might stumble over them.)
    - Put all tools in their proper place.



2. No horseplay! Accidents can result from practical jokes and kidding around. Pay attention to your work.



3. Work only in assigned areas.

    NOTE: All heating and air conditioning work should be done in well-ventilated areas.

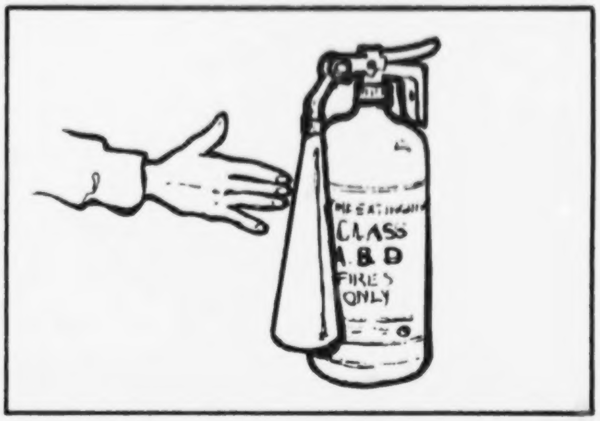
4. Pay attention to hazardous areas:

   - Welding
   - Grinding
   - Electrical
   - Special equipment

OPERATING INSTRUCTIONS

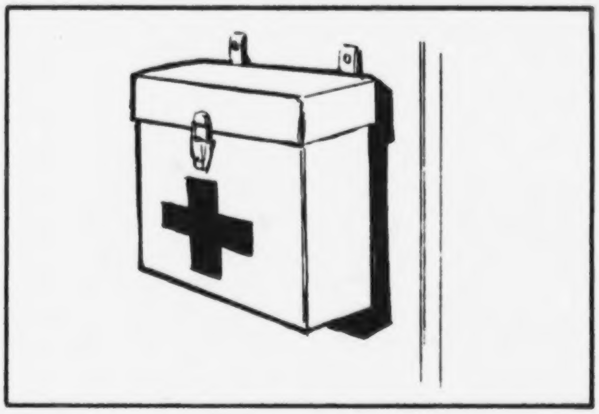
5. Keep all tools sharp and clean.

6. Retain all guards on equipment and never bypass safety devices.



7. Make sure you understand all rules applying to each piece of equipment before startup.

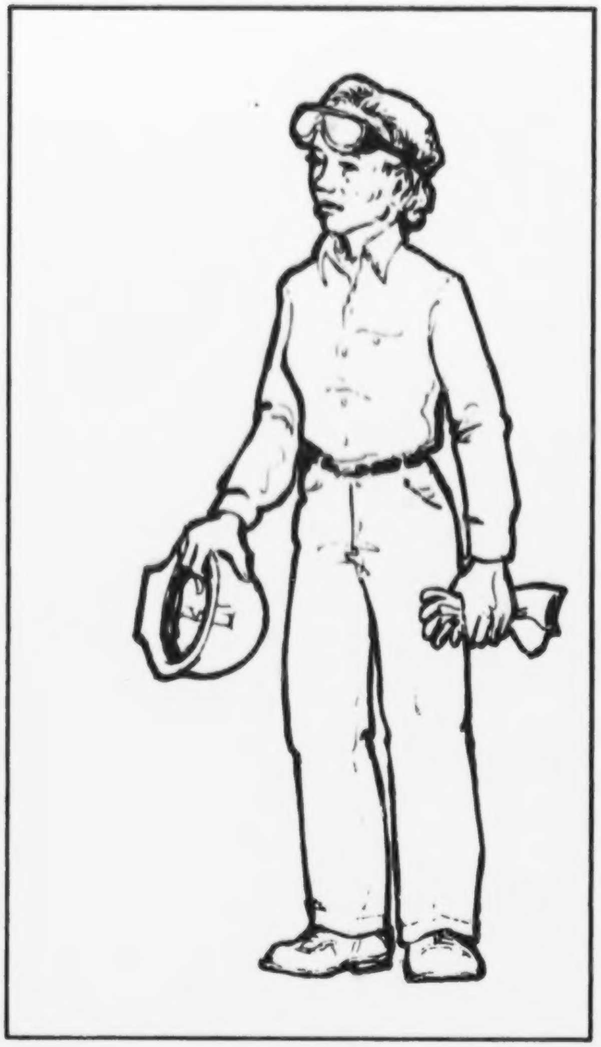
8. Make sure you know the location and type of fire fighting equipment. Find out how to use it. A fire extinguisher should be handy when you are using a torch.



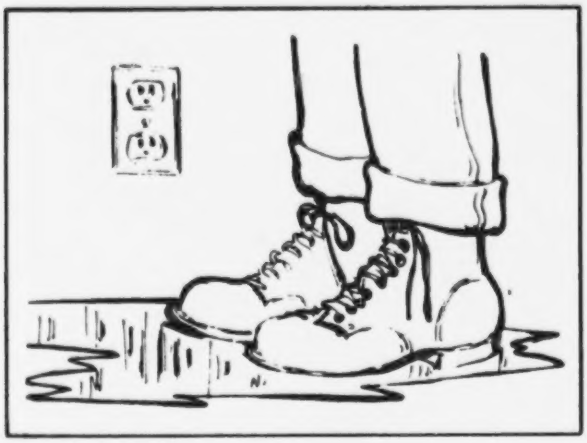
9. Make sure you know the location of the first aid kit and its use. It should be in an obvious place and well marked.

C. Protective Clothing

1. Always wear approved eye protection.
    - Glasses
    - Goggles
    - Helmet
2. Wear clothing suitable to the work situation.
3. Do not wear tennis shoes when working with heavy objects that may fall and injure your foot.
4. Wear rubber gloves when working on high voltage.

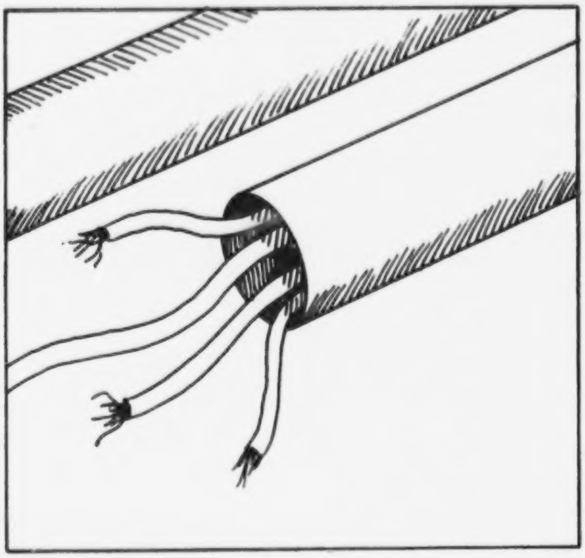


7. Check all circuits for voltage before doing any service work.



8. Stand on dry, nonconductive surfaces when working with live circuits.

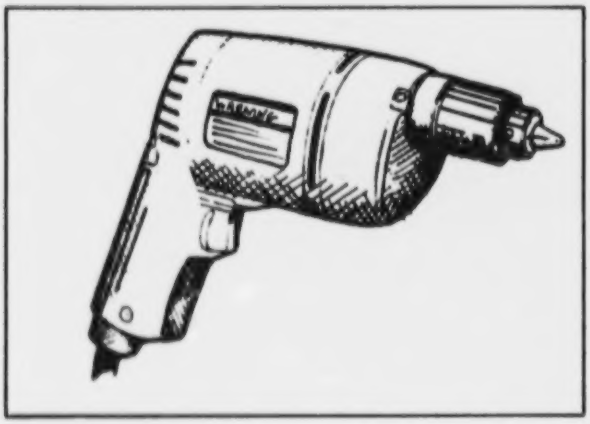
9. Never bypass an electrical protective device.



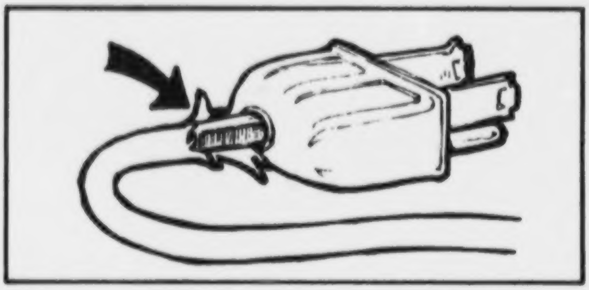
10. Make sure all electrical wires are in a conduit to separate them from refrigerant tubing.

11. Properly insulate all electrical wiring.

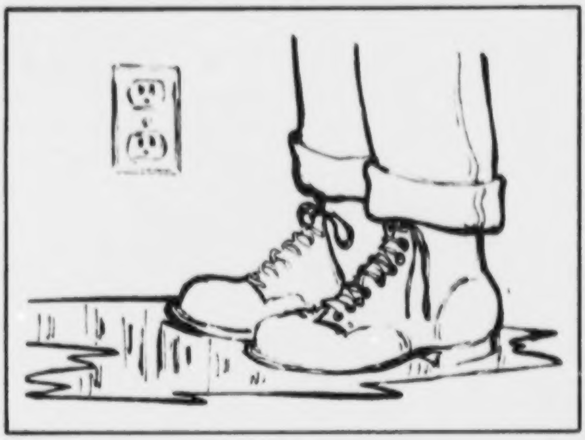
E. Safety Procedures When Using Electrical Tools



1. Read warning labels on all power tools.
2. Have a ground on all power tools.
3. Use proper size electrical cord.



4. Have proper guards on all tools.
5. Do not use tools with frayed or damaged cords.

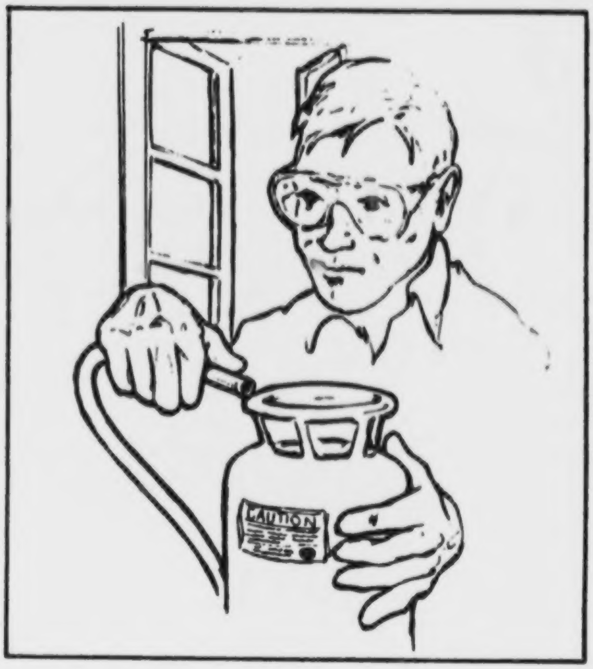


6. Stand on dry, nonconductive surfaces when using electrical tools.

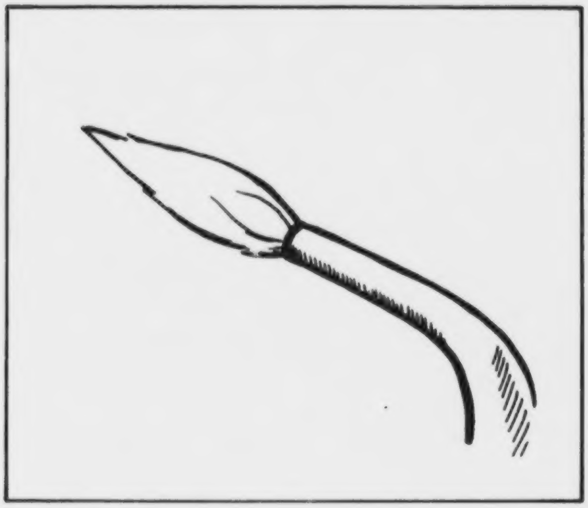
   CAUTION: NEVER TURN ON AN APPLIANCE WHILE STANDING IN WATER.

7. Wear proper eye protection.

F. Safety Procedures for Refrigerants



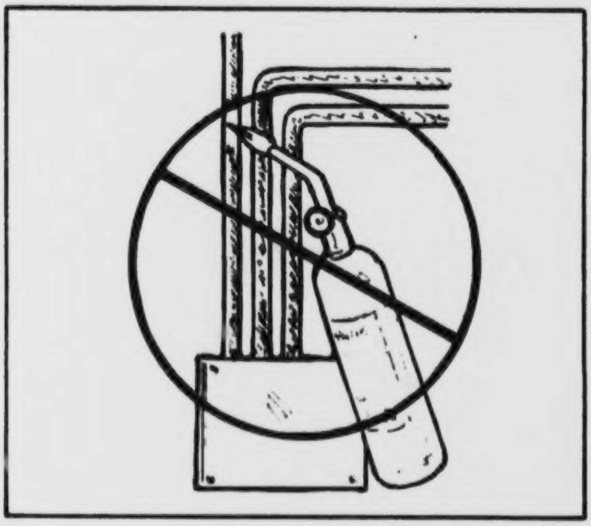
1. Always wear safety glasses with side protection while working on refrigeration systems.
2. Read warning labels on all refrigerant cylinders.
3. Make sure the area is well ventilated when working with refrigerants.



4. Do not inhale (breathe in) refrigerants.
5. Never warm a refrigerant cylinder above 125°F.
6. Never put flame on a refrigerant cylinder.

CAUTION: REFRIGERANT + FLAME = POISONOUS PHOSGENE GAS!

7. Never apply a torch to a sealed refrigeration system.



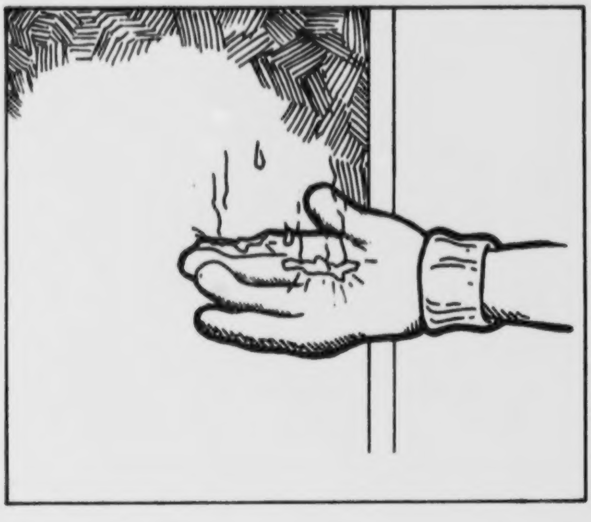
8. Never overpressurize a refrigerant cylinder.

9. Do not pump liquid refrigerant in a compressor because this may cause the compressor to explode.

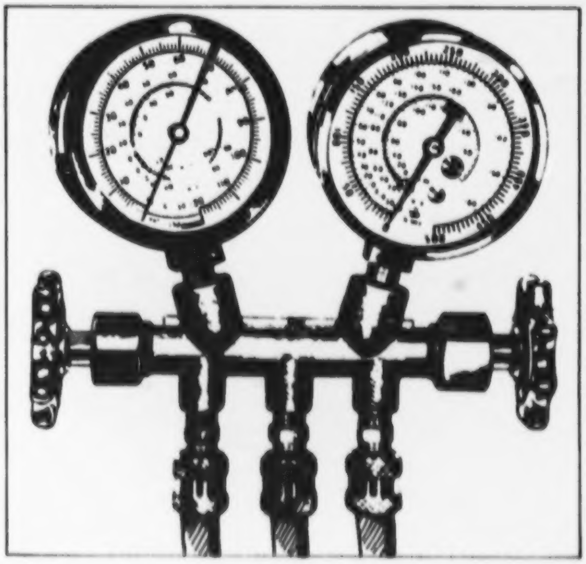
10. Never refill a disposable refrigerant cylinder.

11. Never use acetylene to pressurize a refrigeration system to check for leaks. An explosion may result.

12. Never use oxygen to pressurize a system. The mixing of oxygen and the oil in the system will cause an explosion.



13. Be careful of acids created in a refrigeration system due to moisture or compressor burnout.

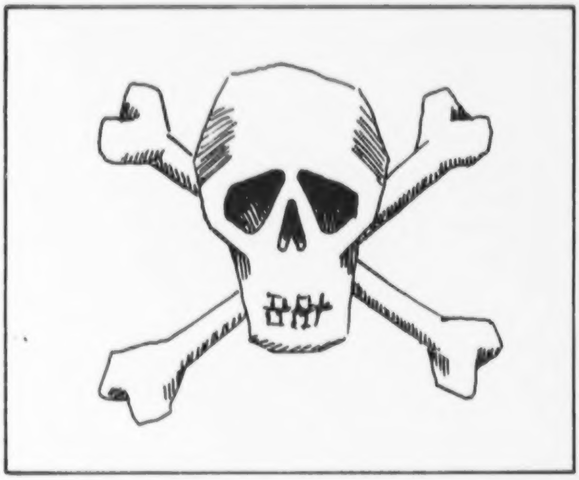


14. Do not use refrigerant lines as supports.

15. Inspect refrigerant line flares before using.

16. Inspect all pressure gauge hoses and connections before using.

17. Back seat valve stems before removing gauge port caps.



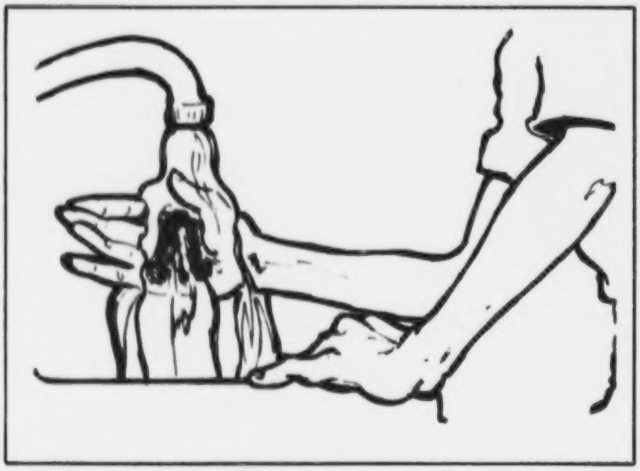
18. Never use carbon tetrachloride as a cleaning solvent because it is extremely poisonous.

19. Use naphtha with a high flash point of 100°F or more for cleaning.

20. Never discharge compressed gases toward any person.

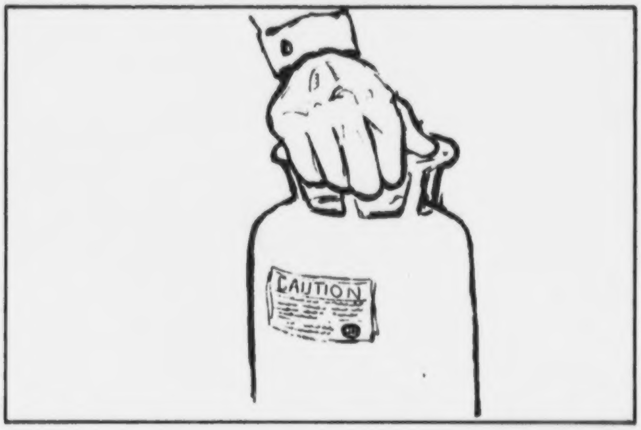
21. Never spray refrigerant directly on the skin.

CAUTION: IF LIQUID REFRIGERANT IS SPRAYED DIRECTLY ON THE SKIN OR IN THE EYES – WASH THE AREA WITH COLD WATER AND GET MEDICAL TREATMENT IMMEDIATELY!



22. Do not mix refrigerants.

23. Replace cylinder cap when not in use to protect valve.



24. Do not lift or carry cylinder by valve. To move a cylinder, always use handles attached to the cylinder or a "dolly" when moving large 125-pound cylinders.

25. Before you discard a disposable refrigerant cylinder, you must either remove the valve or puncture the cylinder.

G. Using First Aid Procedures

> NOTE TO THE INSTRUCTOR: If possible, this information should be presented by a Health Services instructor. A First Aid course might be provided.

If an accident occurs on the job and first aid is needed, knowing the appropriate first aid procedures and acting quickly may prevent serious injury or save someone's life.

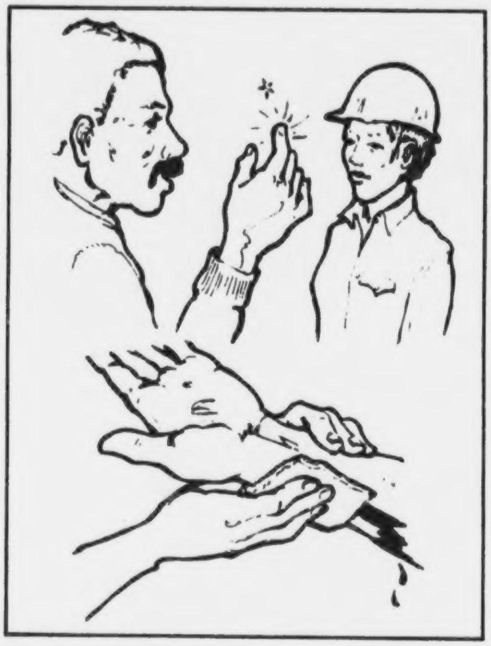
1. Report all accidents and injuries to your instructor.

2. Proper first aid for cuts should stop the bleeding and prevent infection.

   - Press a sterile gauze pad against the cut.

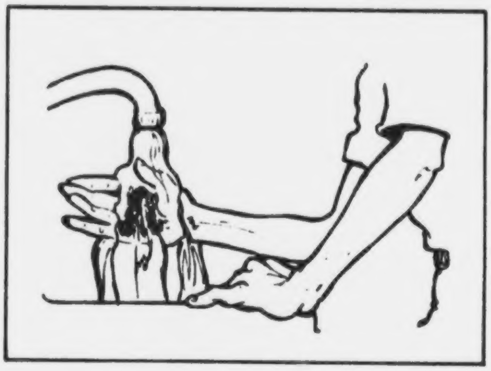
   - Apply pressure while raising the cut area. (Raise it above the heart whenever possible.)

   - When bleeding stops, apply an antiseptic and cover the cut with a clean bandage.



3. Proper first aid for burns helps to reduce and prevent infection.

   - Hold the burned area under cold water or wrap some ice in a clean towel and hold it on the burn for several minutes.



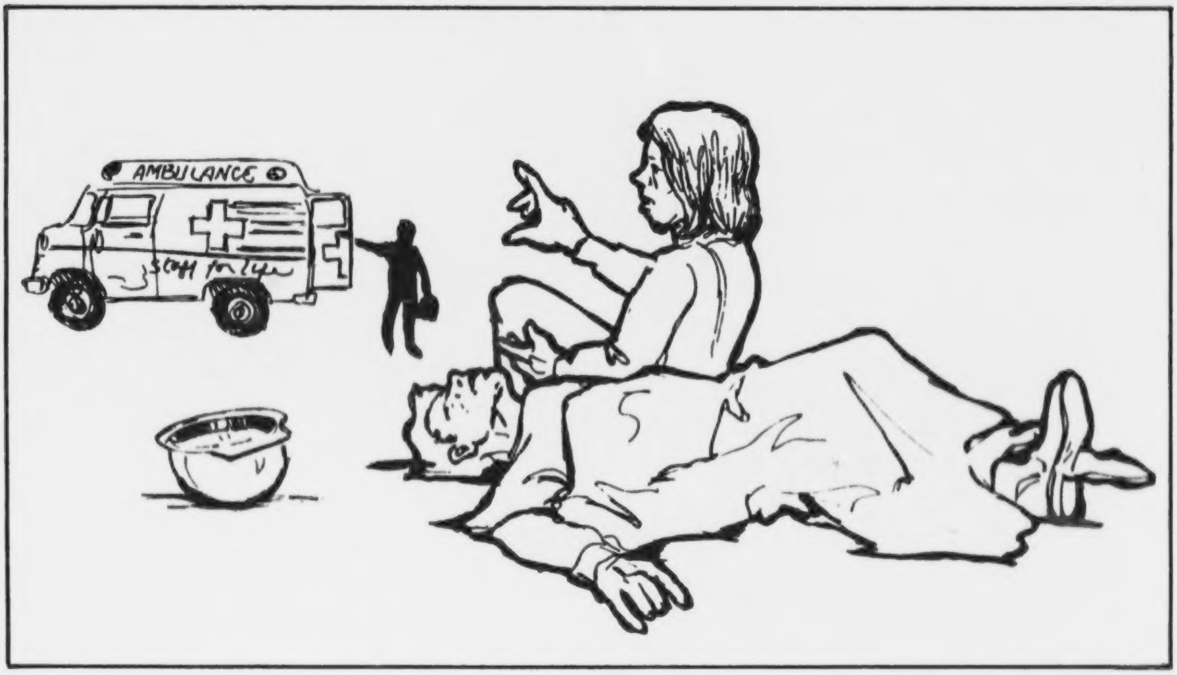
- Apply an antiseptic ointment to the area and cover the burn with a sterile piece of gauze.

4. Proper first aid for severe falls consists of keeping the victim quiet, keeping the victim warm, and calling the doctor immediately.
    - When a fall occurs and a back or neck injury is possible, don't move the victim.

5. Be sure to keep the patient calm and covered in case of shock. Provide adequate ventilation and keep other people away.

NOTE: 911 is often an emergency number to call.

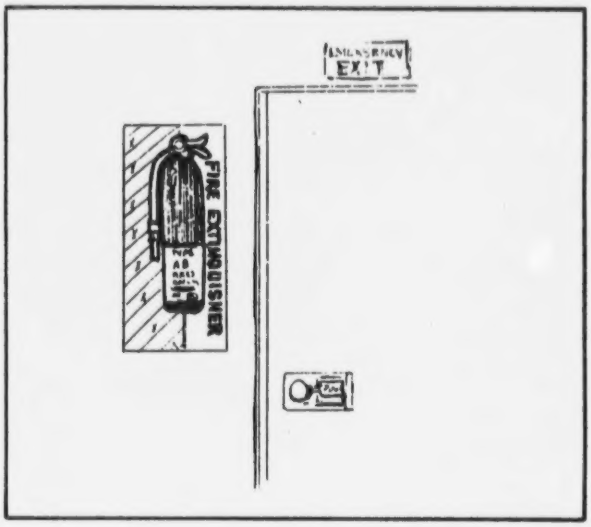
6. After determining how severe a cut, burn, or fall is, summon an ambulance or consult a physician if necessary.



H. Fire Safety Procedures

The best advice for fire safety is to avoid situations which can cause a fire.

1. Know where fire extinguishers are located and know how to use them.

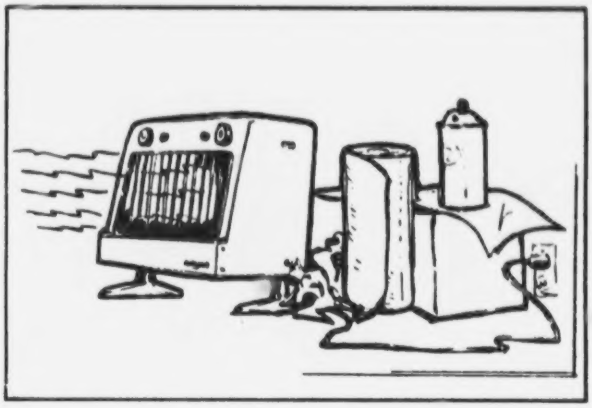


2. Keep fire doors, exits, and stairs free of equipment and materials.

3. Follow appropriate safety procedures when using torches and when working with electrical equipment.

   CAUTION: Never leave equipment unattended when you are using it.

4. Faulty electrical equipment should be reported at once to the supervisor.



5. Do not store paper products or flammable objects near a heat source.

In case of a fire:

- Report any fire immediately to your supervisor.
- Never put water on a grease fire; it will cause the fire to spread.
- Cut off the air supply by smothering the fire. Use a fire extinguisher, damp cloth or nonflammable cover to do this.

NOTE: Multipurpose extinguishers can be used on all types of fires.

ORDINARY FIRE (Class A)	How It Starts: Paper, wood, or fabric gets too close to a heat source and ignites.
	How To Extinguish It: - Use Water - Smother it with a damp cloth - Use Class A or multipurpose fire extinguisher
GREASE FIRE (Class B)	How It Starts: Grease or oil gets too hot or comes close to a heat source.
	How To Extinguish It: - Smother it with a damp cloth - Use Class B or multipurpose fire extinguisher
ELECTRICAL FIRE (Class C)	How It Starts: Electrical shorting or faulty wiring
	How To Extinguish It: - Use Class C or multipurpose fire extinguisher

6. To produce fire, three things must be present at the same time:

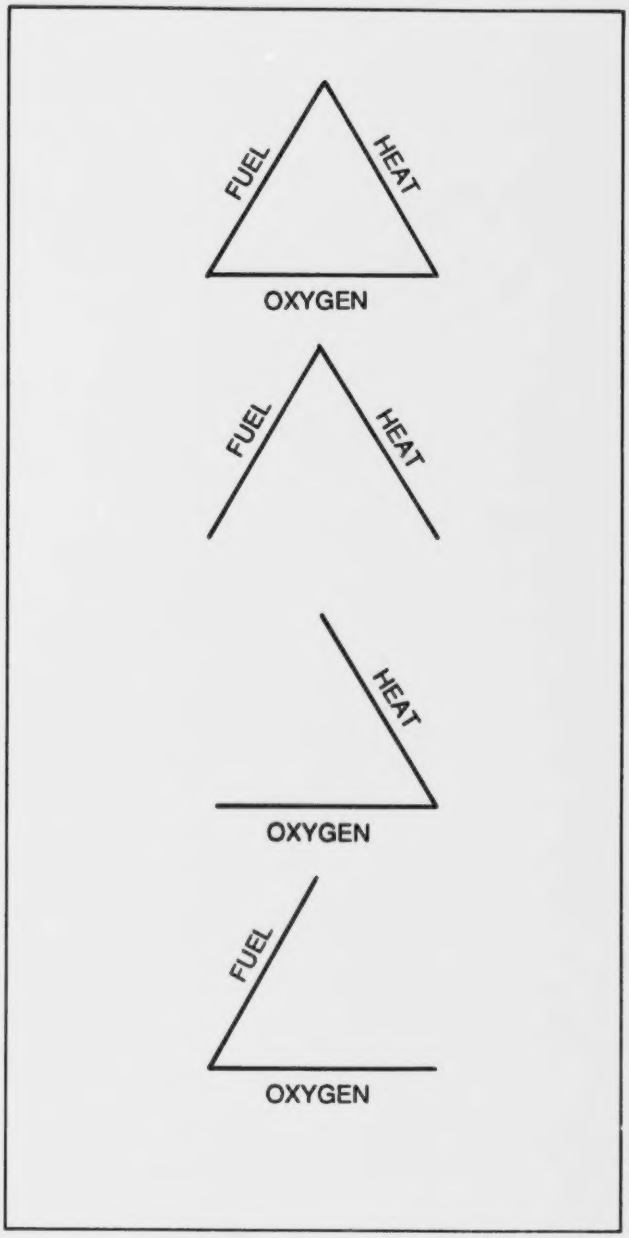
   - Heat

   - Oxygen

   - Fuel or combustible material (anything that will burn)

   If any one of these three things is missing or is removed, there cannot be fire.

   NOTE: When working with a torch, you must have heat and oxygen--so you must be sure there is no combustible material near the flame that could catch on fire.


FUEL
HEAT
OXYGEN
FUEL
HEAT
HEAT
OXYGEN
FUEL
OXYGEN

H. Safety Colors

Special colors are used to indicate safety equipment, as well as safety hazards.

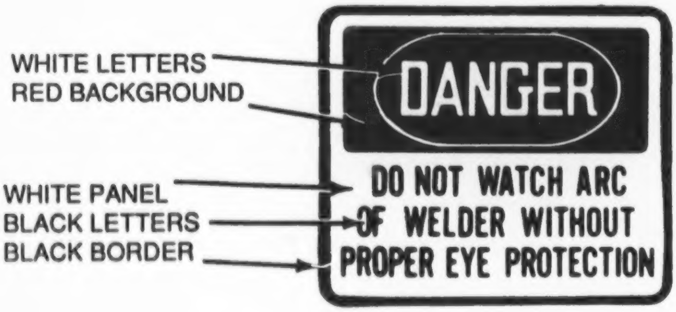
Red - is used for location of fire fighting equipment, portable containers for flammable liquids and emergency switches for machinery.

Yellow - Caution and marking physical hazards

Orange - Dangerous parts of machines

Purple - Radiation hazards

Green - Safety and first aid equipment


WHITE LETTERS
RED BACKGROUND
WHITE PANEL
BLACK LETTERS
BLACK BORDER
DANGER
DO NOT WATCH ARC
OF WELDER WITHOUT
PROPER EYE PROTECTION

DO SKILL SHEET 1.

DO ACTIVITY SHEET 1.

SAFETY

SKILL SHEET 1

Directions: Put a mark beside each statement that tells a practice you currently use in your laboratory setting. Afterwards, circle the numbers of the statements that are examples of safety practices you should follow in the lab.

YES	NO		DO YOU:
__	__	1.	Work only in assigned areas?
__	__	2.	Always wear approved eye protection?
__	__	3.	Understand all rules applying to each piece of equipment before startup?
__	__	4.	Put all tools in their proper place?
__	__	5.	Pay attention while operating equipment?
__	__	6.	Retain all guards and safety devices?
__	__	7.	Always wear rubber gloves when working on high voltage?
__	__	8.	Wipe up spills immediately?
__	__	9.	Report defective equipment?
__	__	10.	Keep floors free of dirt, scraps, and parts?
__	__	11.	Keep work areas clean and orderly?
__	__	12.	Wear safe work shoes?
__	__	13.	Know where the fire extinguishers are located?
__	__	14.	Know how to use fire extinguishers?
__	__	15.	Know the location of the first aid kit?
__	__	16.	Read warning labels on equipment?
__	__	17.	Lock off or tag switches controlling high voltage when the circuit is being worked on?
__	__	18.	Know what steps to take in case of accident and injury?

SAFETY

ACTIVITY SHEET 1

Directions: Your instructor will take you on a tour of the shop area. He/she will point out hazardous areas, tool and equipment storage, supplies, first aid kits, fire extinguishers, assigned work areas, and clean up equipment.

Make a drawing of the shop showing the location of all of the things listed above.

SAFETY

UNIT REVIEW

Directions: Put an "x' in front of each correct statement about shop safety.

____ 1. Accidents can happen when there are practical jokes and horseplay in the shop.
____ 2. Accidents can happen in any area of the shop you work in.
____ 3. Approved eye protection should always be worn.
____ 4. Never turn an appliance on while standing in water.
____ 5. All tools should be kept sharp and clean.
____ 6. Fire safety must be practiced everywhere in a shop.

Directions: Circle the best word(s) in each sentence to make a safety rule.

7. Only work with refrigerants in a well (shaded, ventilated) area.

8. If you spill something, (walk around it, wipe it up).

9. Apply (pressure, warmth) to a cut to help stop bleeding.

10. Store oily rags in a (closed metal container, cardboard box).

11. When working with electricity, use tools that have (insulated, rough) handles.

12. If you drop something pick it up (right away, later).

Directions: Circle the letter of the correct answer for each statement below. Statements may have more than one correct answer.

13. When working on high voltage, wear:
    a. Leather shirt
    b. Rubber gloves
    c. Goggles

14. Good safety rules for refrigerants are:
    a. Wear safety glasses.
    b. Never use an open flame to heat up a refrigerant tank.
    c. Don't worry about warning labels.

Directions: Match the color to its safety meaning.

____ 1. Red

____ 2. Orange

____ 3. Yellow

____ 4. Green

____ 5. Purple

a. Safety and first aid equipment

b. Location of firefighting equipment and emergency switches for machinery

c. Radiation hazards

d. Caution, physical hazards

e. Dangerous parts of machines

SAFETY

PERFORMANCE CHECKLIST

Student ______________________ has successfully performed the following steps of procedure.

Procedures	Yes	No	Comments
1. Followed general shop safety procedures a. Kept work area clean			
b. Put tools in proper place			
c. Attended to work and avoided horseplay			
d. Worked only in assigned areas			
e. Showed caution of hazardous areas			
f. Kept tools sharp and clean			
g. Retained all guards and safety devices			
h. Followed rules for each piece of equipment			
i. Identified location of fire equipment and how to use it			
j. Identified location of first aid kit			
2. Wore appropriate protective clothing a. Wore approved eye protection			
b. Wore suitable clothing for work situation			
c. Wore rubber gloves when needed			
3. Followed electrical safety procedures			
4. Followed safety procedures for electrical tools			

Procedures	Yes	No	Comments
5. Worked on dry, nonconductive surfaces			
6. Followed safety procedures for refrigerants			
7. Followed first aid procedures			
8. Followed fire safety procedures			
9. Recognized the use and meanings of colors to indicate safety equipment and hazards			

Satisfactory - Should Move On ☐

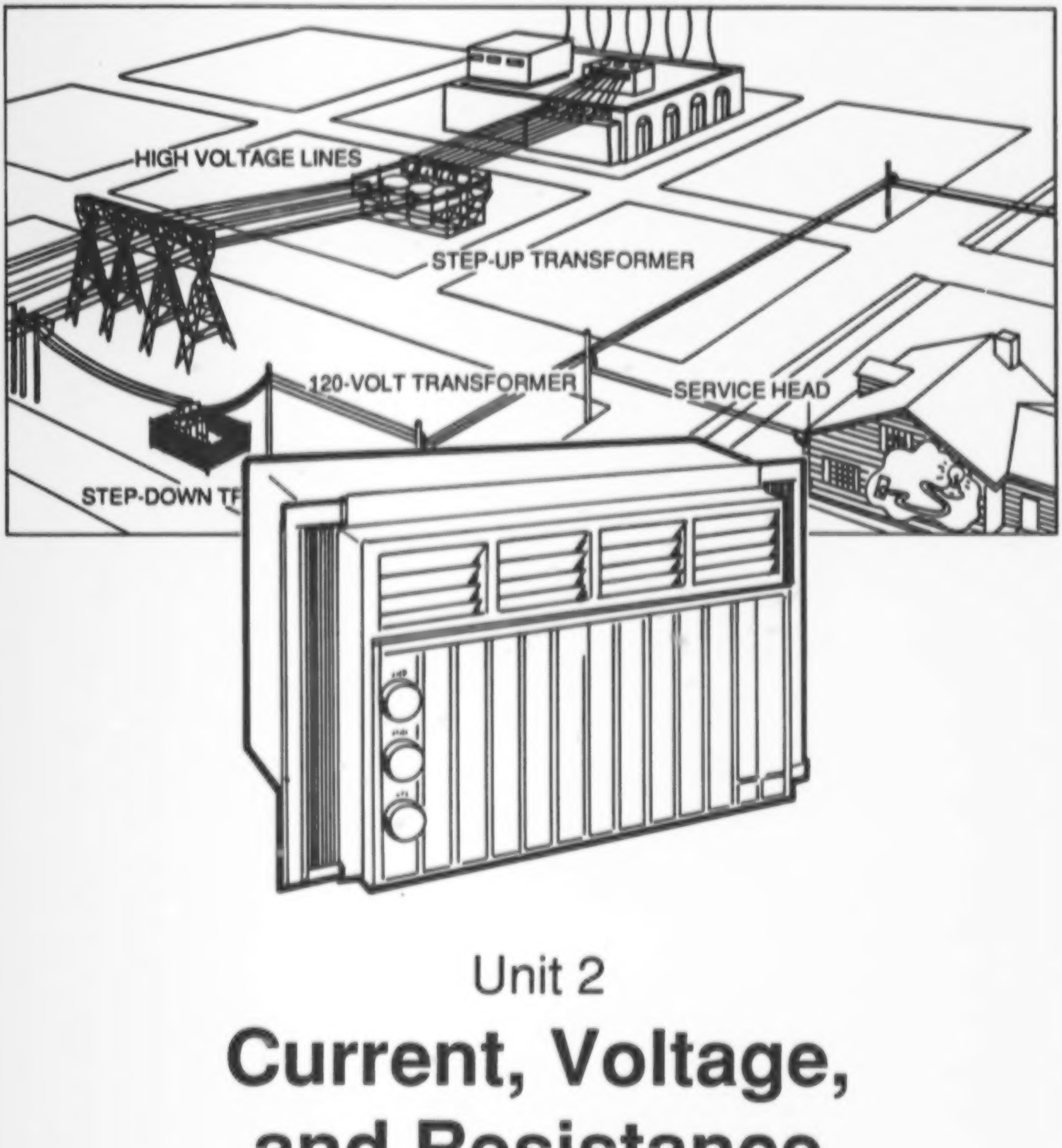
Repeat This Unit ☐

Student's Signature/Date

Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 2

Current, Voltage, and Resistance

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

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DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

CURRENT, VOLTAGE AND RESISTANCE

INTRODUCTION

Main properties of any electrical circuit are current, voltage, and resistance. In order to perform any electrical maintenance or repair on air conditioning/ refrigeration units, you must understand these electrical properties and be able to use the proper equipment to test and measure current, voltage, and resistance.

This unit covers terms, test equipment, and steps of procedure for measuring current, voltage, and resistance in an electrical circuit. Safety is also an important part of electricity and you should not use any test equipment until you know how electricity as well as the test equipment works.

UNIT OBJECTIVES

After completing this unit, you should be able to use test equipment to measure current, voltage, and resistance and detect common electrical problems in a circuit.

SPECIFIC OBJECTIVES

1. Identify and distinguish between current, voltage, and resistance.
2. Measure current with a clamp-on meter.
3. Measure voltage with a clamp-on meter.
4. Measure resistance (ohms) with a selector-switch multimeter.

Are You Ready?

Check the Statement that Fits You Best

☐ I can do these tasks and want to go through the Performance Checklist.

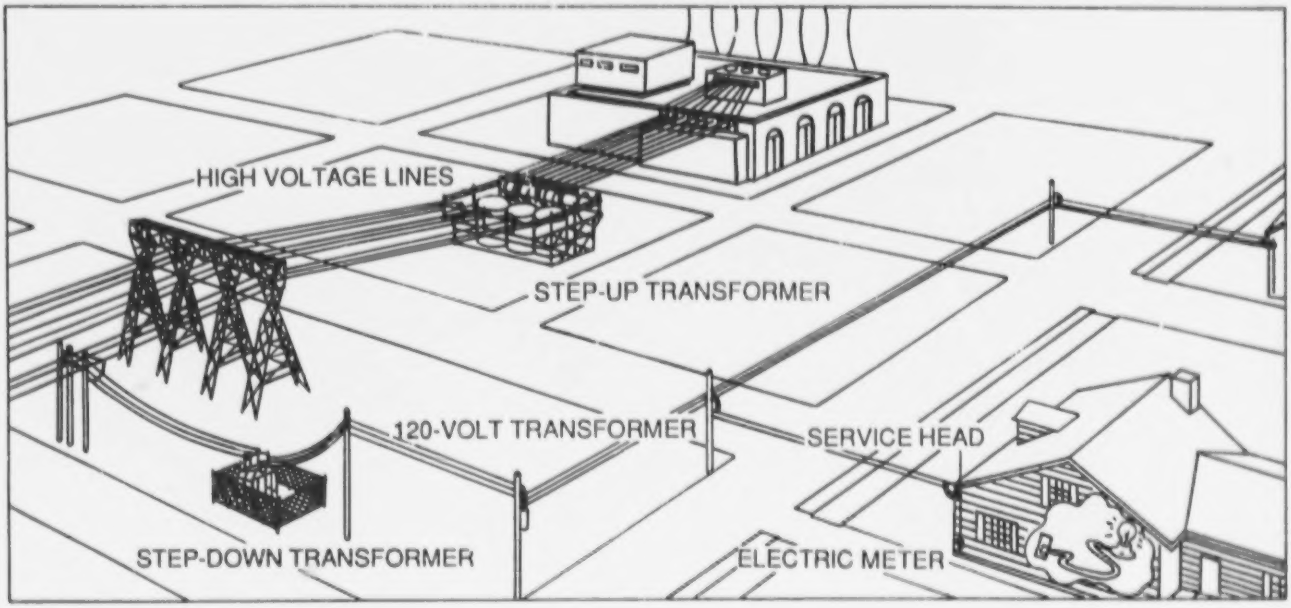
SEE YOUR INSTRUCTOR

☐ I want to study the information in this unit before I do the Performance Checklist.

TURN PAGE AND BEGIN

A. Terms and Equipment for Current, Voltage and Resistance
Terms

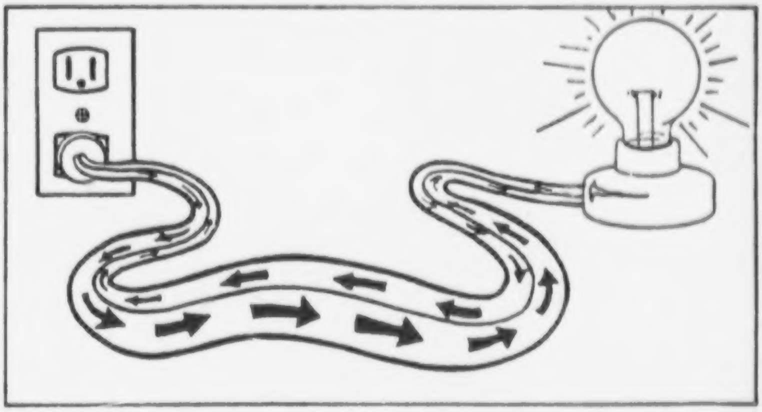
1. Electricity - energy that can be used to produce light, heat, or motion.


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TRANSFORMER
ELECTRIC METER

2. Current - electricity moving through a conductor.

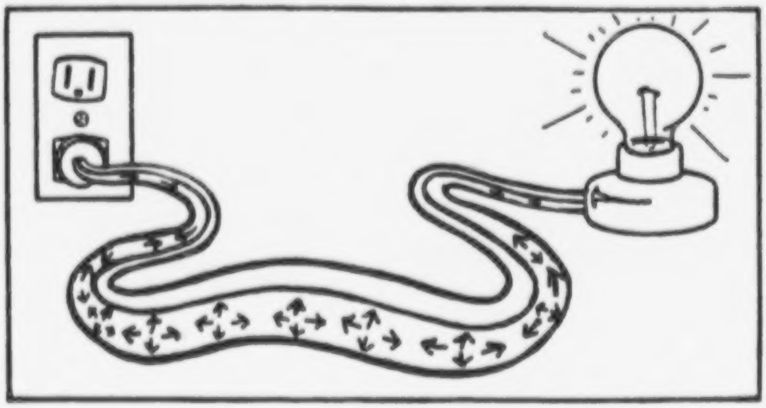
3. Circuit - the complete path of electrical flow.

4. Ampere (amp) - unit of measure telling how much current is moving through a conductor, determined by voltage and resistance.



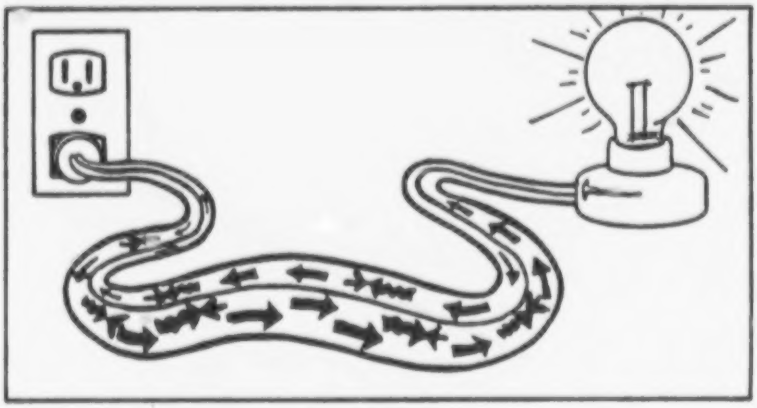
5. Voltage - electrical pressure that pushes current through a conductor.

   Volt - unit of measure for the amount of electrical pressure.



6. Resistance - opposition to current flow in a conductor.

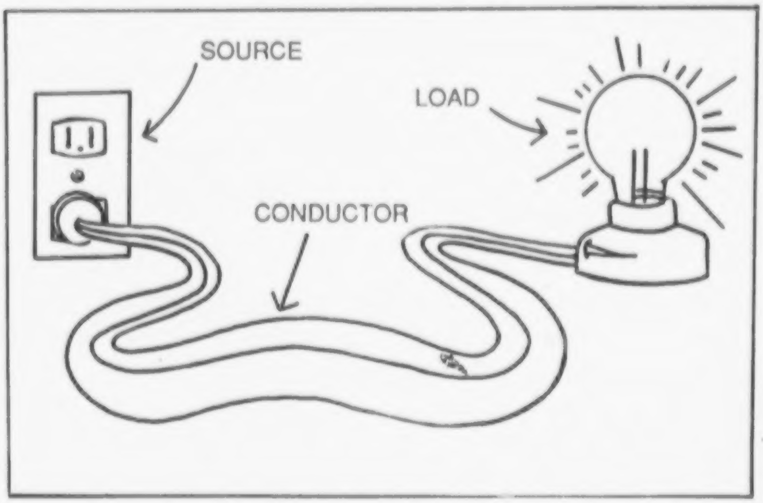
7. Ohm - unit of measure that tells how much resistance is in a line.



8. Load - anything that draws electrical energy from a circuit.

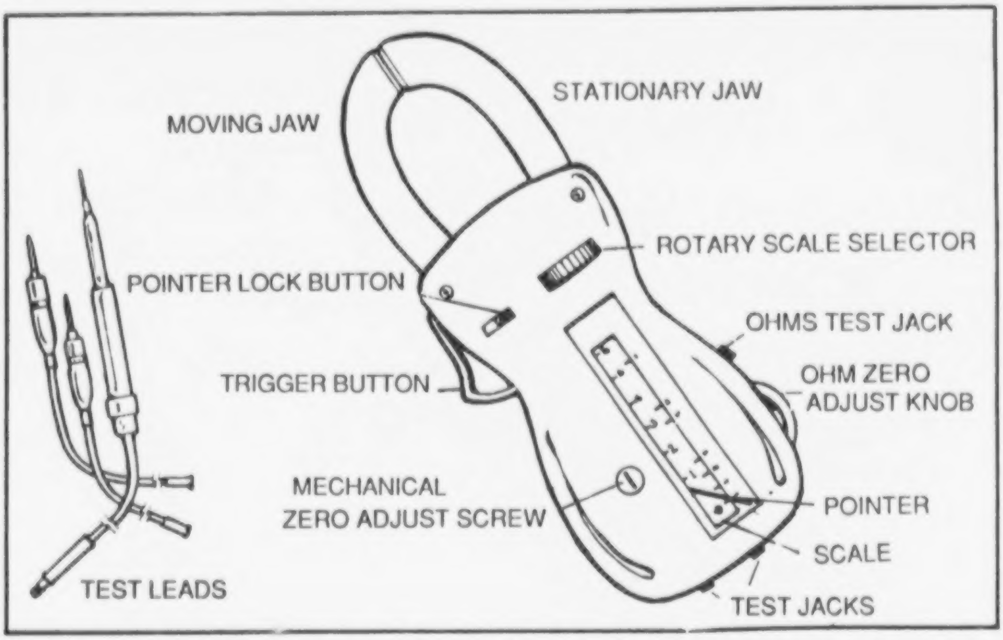
9. Source - anything that supplies voltage to the circuit.

10. Conductor - connection between the load and the source.

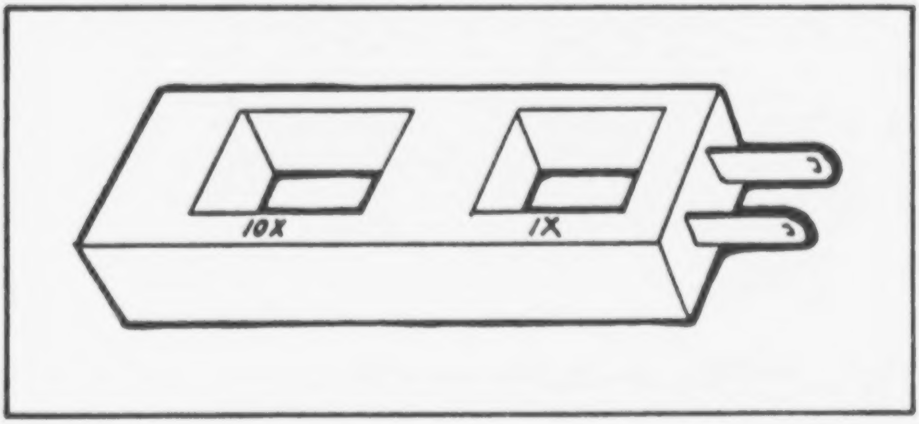


Equipment

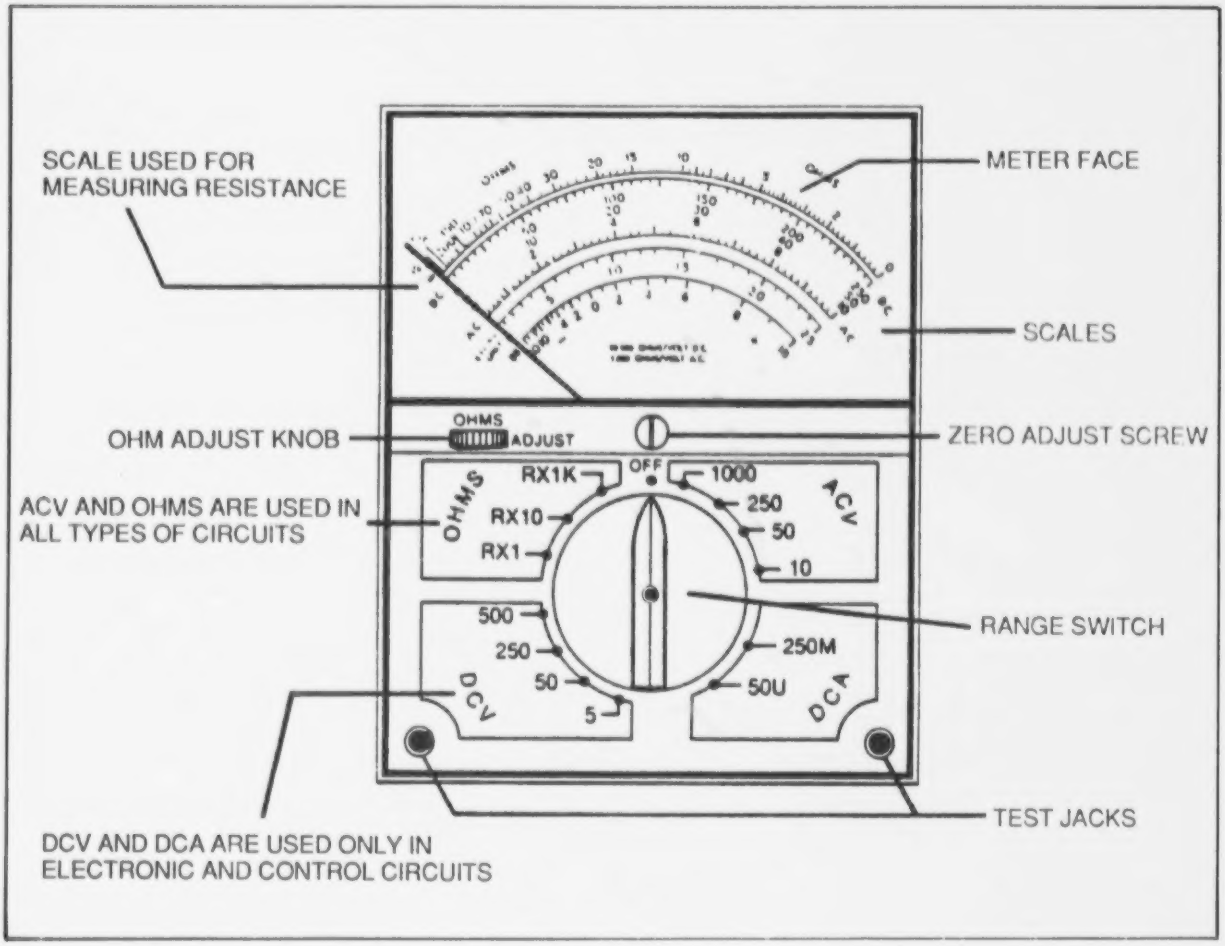
1. Clamp-on meter - electrical instrument used to test for current, voltage, and resistance on alternating current.


MOVING JAW
STATIONARY JAW
ROTARY SCALE SELECTOR
POINTER LOCK BUTTON
OHMS TEST JACK
TRIGGER BUTTON
OHM ZERO ADJUST KNOB
MECHANICAL ZERO ADJUST SCREW
POINTER
SCALE
TEST LEADS
TEST JACKS

2. Line splitter - used to measure current in a two conductor plug-in cord.



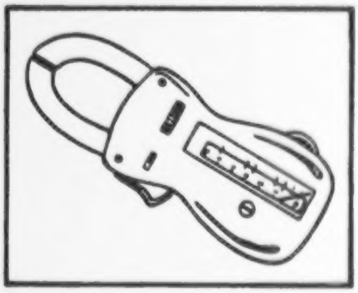
3. Selector-switch multimeter - electrical instrument used to measure voltage and resistance.


SCALE USED FOR MEASURING RESISTANCE
METER FACE
SCALES
OHM ADJUST KNOB
OHMS ADJUST
ZERO ADJUST SCREW
ACV AND OHMS ARE USED IN ALL TYPES OF CIRCUITS
OHMS
RX1K
RX10
RX1
OFF
1000
250
50
10
ACV
RANGE SWITCH
500
250
50
5
DCV
250M
50U
DCA
TEST JACKS
DCV AND DCA ARE USED ONLY IN ELECTRONIC AND CONTROL CIRCUITS

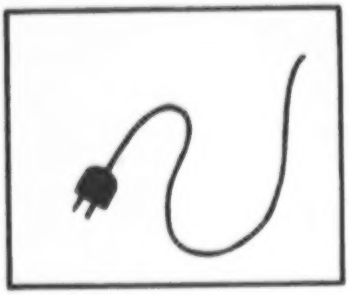
78

B. Steps of Procedure for Measuring Current with a Clamp-On Meter

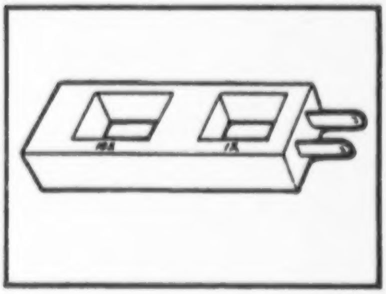
1. Assemble equipment and materials.



Clamp-On Meter



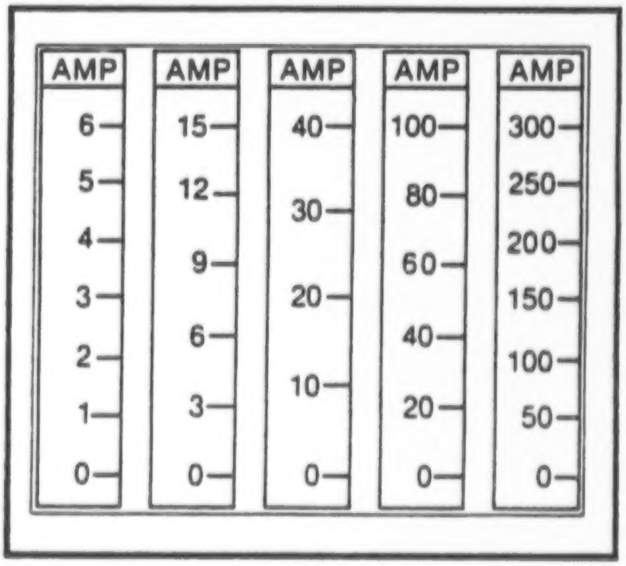
Extension Cord



Line Splitter

2. Turn the rotary cycle scale selector on the clamp-on meter and look at amp scales:

   0 - 6 AMPS
   0 - 15 AMPS
   0 - 40 AMPS
   0 - 100 AMPS
   0 - 300 AMPS

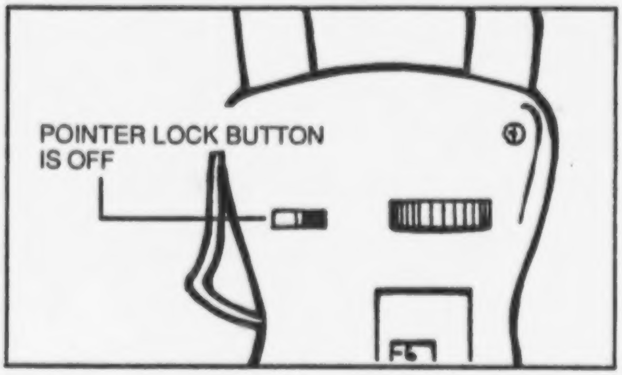

AMP
6
5
4
3
2
1
0
AMP
15
12
9
6
3
0
AMP
40
30
20
10
0
AMP
100
80
60
40
20
0
AMP
300
250
200
150
100
50
0

3. Select a scale that is higher than the amount of current you want to measure by turning the rotary scale selector to that range.

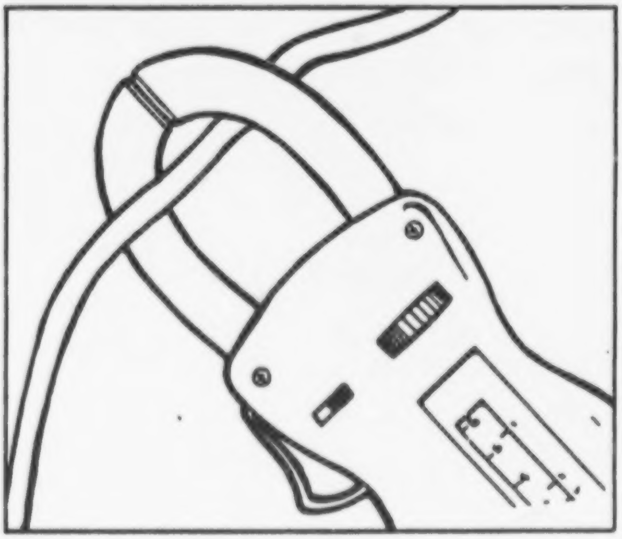
NOTE: If you do not know the amount of current to expect, use the scale with the highest number.

---

4. Check that the pointer lock button is in the left position (OFF).



NOTE: While the meter is clamped around the wire, you may not be able to see the scale. In this case, move the pointer lock button to the right. This will lock the reading on the scale. Then you can check the reading after the clamp-on meter is removed.



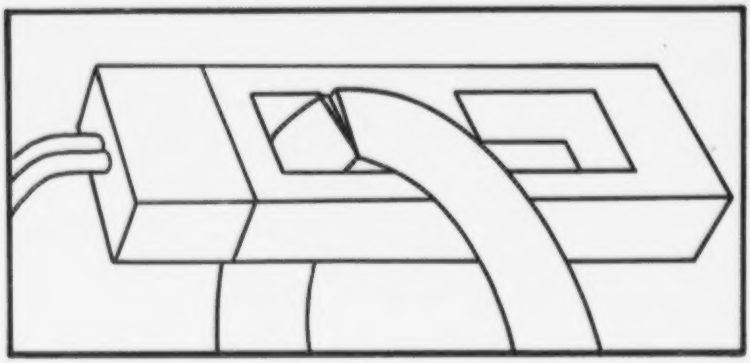
5. Press the trigger button to open jaws. Place jaw around ONE conductor and release the trigger button.

   CAUTION: Make sure the conductor is not caught in the jaw opening - it will burn up the meter.

NOTE: If jaws are around more than one wire, meter will not work.

6. If the pointer indicates below 100 amps, turn to the next lower scale. If the pointer is below 40 amps, turn to the next lower scale. Continue turning until the reading is on the upper half of the scale.

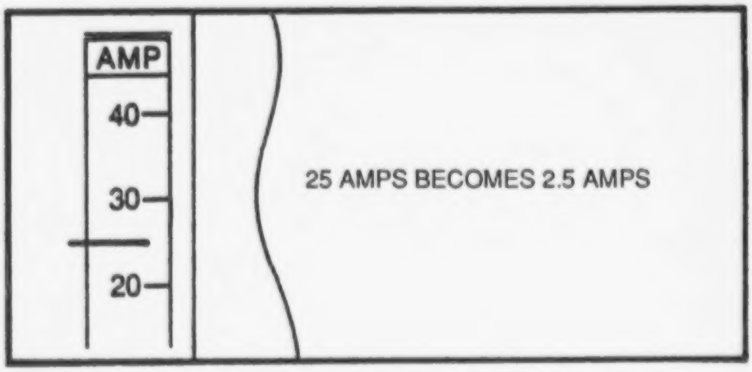
7. To measure the amount of current flowing in a two conductor plug-in cord, plug the cord into the back of the line splitter.



8. Plug the extension cord into the wall outlet and place the jaws through the 1X hole.

9. Take a reading from the clamp-on meter.

10. To measure small amounts of current, place jaws through the 10X hole.



11. Take a reading from the clamp-on meter.

12. Check the reading on the clamp-on scale. Put a decimal point before the last digit in the number to get the correct reading.

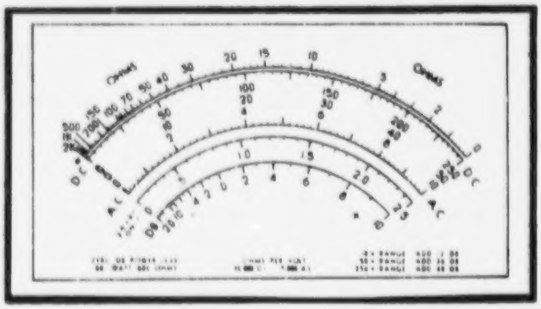
Do Skill Sheet 1
Do Activity Sheet 1.

CURRENT, VOLTAGE, AND RESISTANCE
SKILL SHEET 1:
READING VOLTAGE ON A SELECTOR-SWITCH MULTIMETER

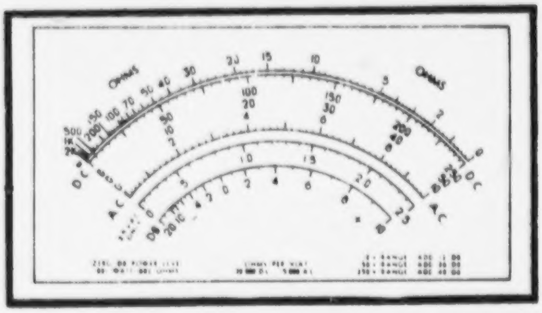
Directions: Use a straight edge to draw in the pointer to show the following:

CAUTION:THIS IS A PAPER-AND-PENCIL ACTIVITY. DO NOT ACTUALLY ATTEMPT TO TAKE THESE READINGS.

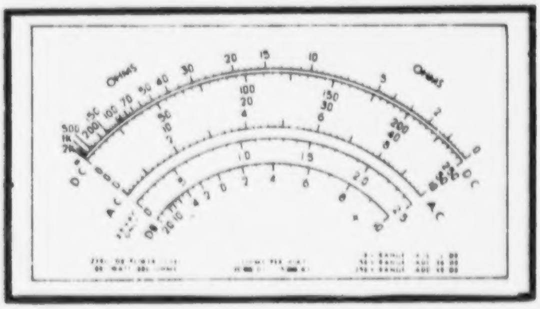
1. An open circuit reading.



2. 230 volts when the range switch is at 250 ACV.



3. 24 volts when the range switch is at 50 VAC.



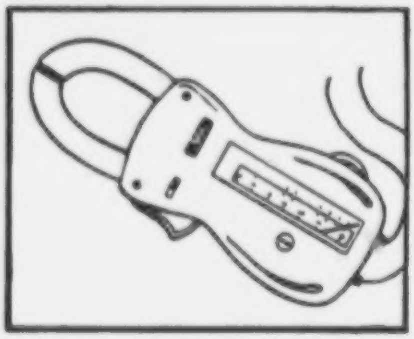
CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 1: MEASURE CURRENT

Directions: Follow the steps below to measure current.

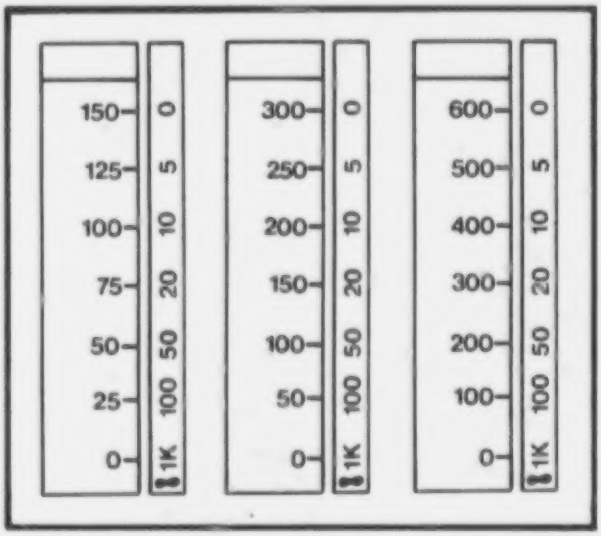
1. Ask your instructor to watch you do this procedure.
2. Plug a lamp into the end of a line splitter. Then plug the line splitter into a wall outlet.
3. Turn on the lamp with a 100 watt bulb.
4. Measure current as shown in the steps of procedure.
5. Record you reading: _______________ amps
6. Repeat above steps with a 25 watt bulb in the lamp.
7. Record your reading: _______________ amps

C. Steps of Procedure for Measuring Voltage with a Clamp-On Meter

1. Assemble equipment and materials.


CLAMP ON METER

2. Turn the rotary selector on the clamp-on meter and look at the volt scales.
   0 - 150 VOLTS
   0 - 300 VOLTS
   0 - 600 VOLTS


150
125
100
75
50
25
0
0
5
10
20
50
100
1K
300
250
200
150
100
50
0
0
5
10
20
50
100
1K
600
500
400
300
200
100
0
0
5
10
20
50
100
1K

NOTE: On many meters, the volt scale is printed in red.

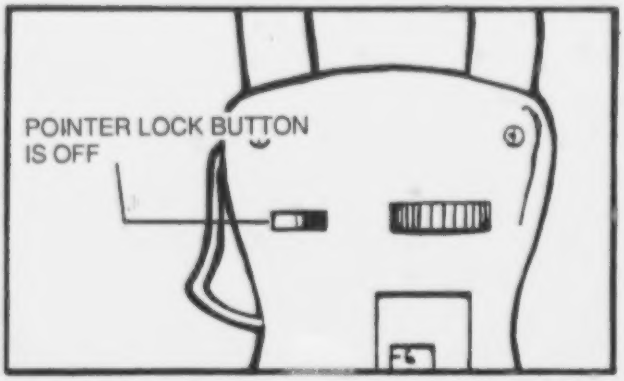
---

3. Select a scale that is higher than the amount of voltage you want to measure.

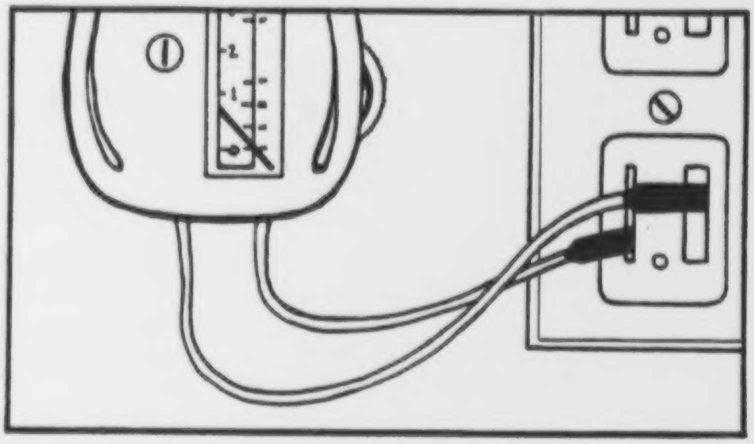
NOTE: If you do not know what voltage to expect, use the scale with the highest number.

---

4. Check that the pointer lock button is in the left position.

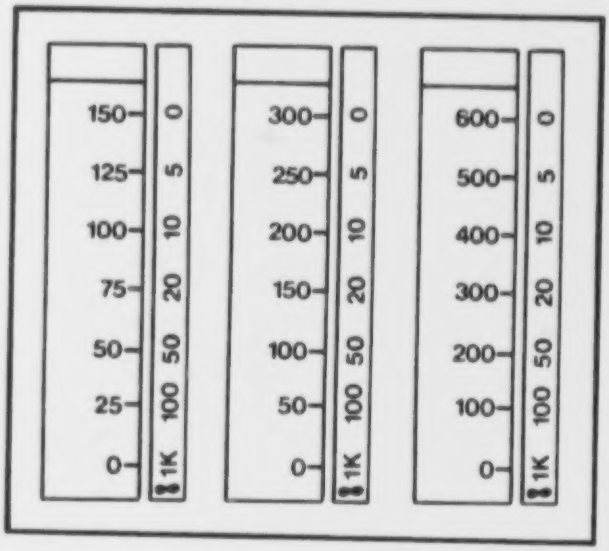

POINTER LOCK BUTTON IS OFF

5. Plug the test leads into the bottom of the meter by pushing them over the pin and giving a 1/4 turn.



6. Touch the test leads to the point where you want to measure voltage. Turn to a lower scale until the reading is in the upper half of the scale.

7. Record the reading from the scale.


150
125
100
75
50
25
0
0
5
10
20
50
100
1K
300
250
200
150
100
50
0
0
5
10
20
50
100
1K
600
500
400
300
200
100
0
0
5
10
20
50
100
1K

Do Activity Sheet 2.

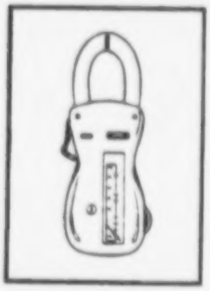
CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 2: MEASURE VOLTAGE

Directions: Follow the steps below to measure voltage.

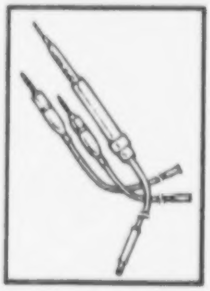
1. Ask your instructor to watch you do this procedure.
2. Set up the meter to measure voltage as shown in the steps of procedure.
3. Measure the voltage at a wall outlet.
4. Record your reading: ________________ volts

D. Steps of Procedure for Measuring Resistance with Clamp-On Meter

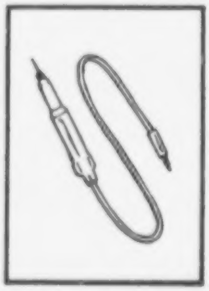
1. Assemble equipment and materials.



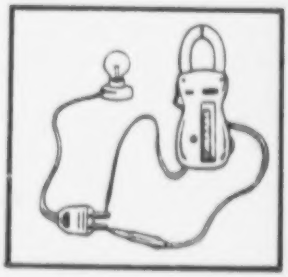
Clamp-On Scale



Test Leads

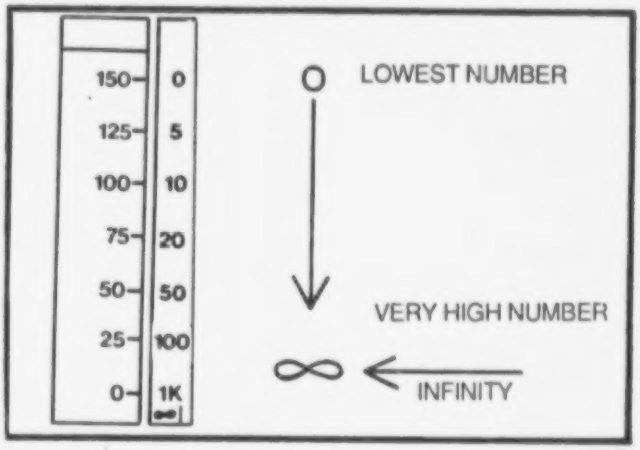


Ohm Meter
ATTACHMENT LEAD



Test Circuit

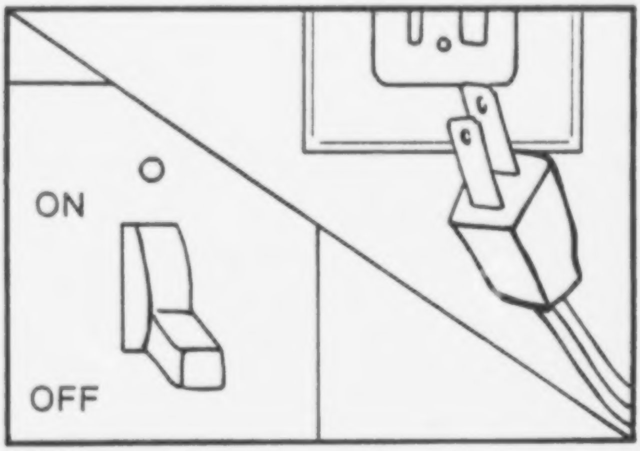
2. Study the ohm scale located on the flat plate to the right of the window.


150
125
100
75
50
25
0
0
5
10
20
50
100
1K
∞
O
LOWEST NUMBER
VERY HIGH NUMBER
∞
INFINITY

NOTE: The ohm scale does NOT move when the rotary scale selector is turned. This scale starts with zero (0) at the top of the scale. The numbers get bigger until they reach infinity (∞) at the bottom.

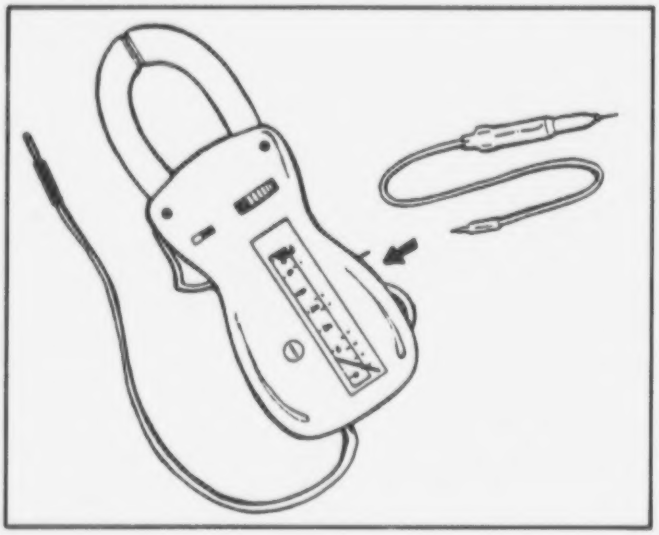
---

3. Turn off the power to the circuit being tested or disconnect the plug.

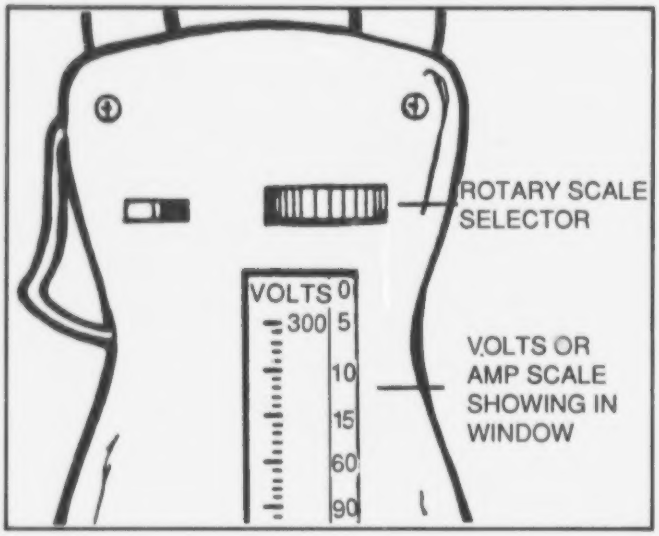


4. Plug only the left voltage test-lead into the bottom of the clamp-on meter.

5. Locate the ohmmeter attachment lead and plug it into the right side of the clamp-on meter below the ohm zero adjust knob.

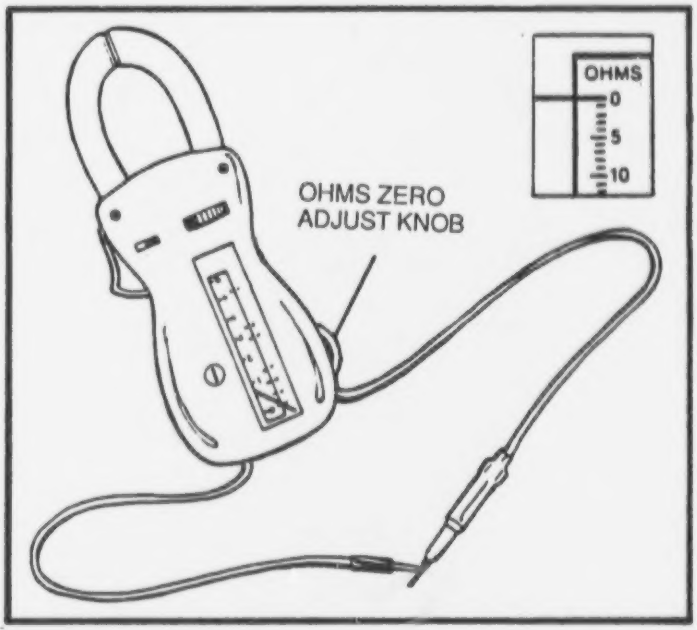


6. Observe the ohms scale in the window.


ROTARY SCALE SELECTOR
VOLTS OR AMP SCALE SHOWING IN WINDOW
VOLTS 0
300 5
10
15
60
90

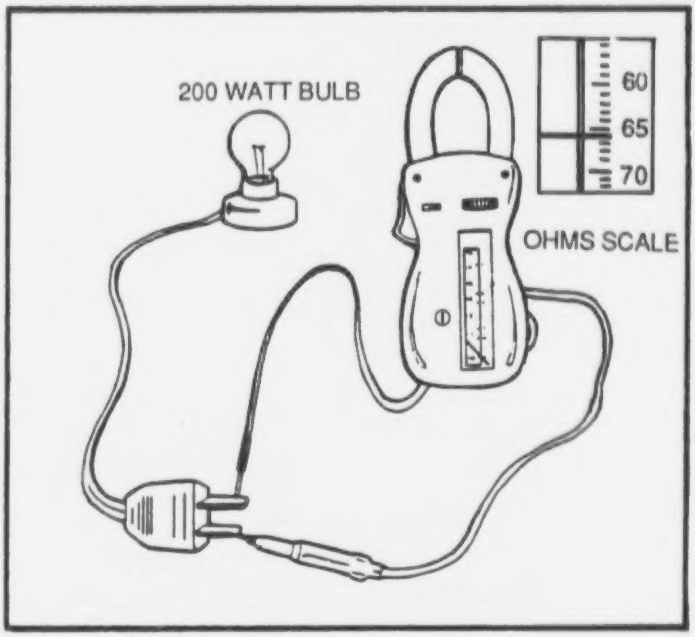
88

7. Short the test leads by touching them to each other.



8. Line the pointer up with zero (0) on the ohm scale by turning the ohms zero adjust knob.

9. To measure resistance between any two points in a circuit, touch the leads to the points and read the pointer on the ohms scale.



NOTE: When measuring resistance of a component in a circuit, one of the conductors to that component must be removed to get a true reading. Reconnect wire after measuring resistance.

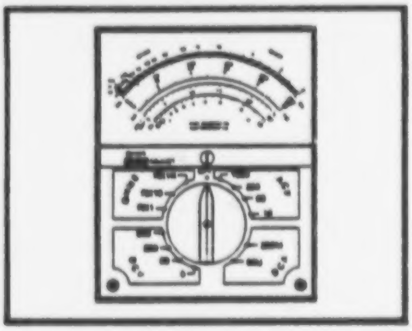
---

10. When finished, store the meter with the ohm test leads disconnected.

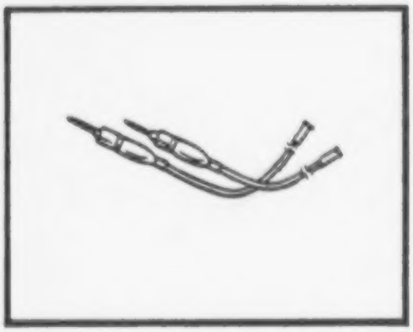
89

E. Steps of Procedure for Measuring Resistance (Ohms) with a Selector-Switch Multimeter

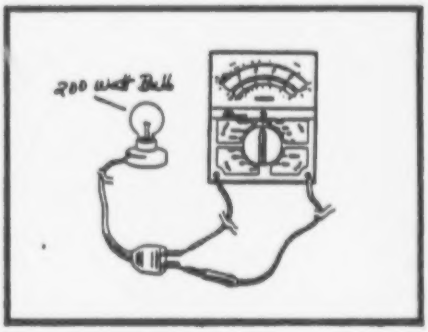
1. Assemble equipment and materials.



Selector-Switch Multimeter

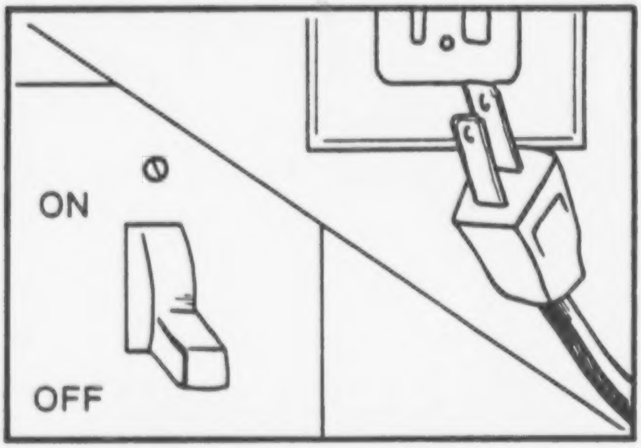


Test Leads



Light circuit

2. Turn off power or unplug circuit before testing with the meter.

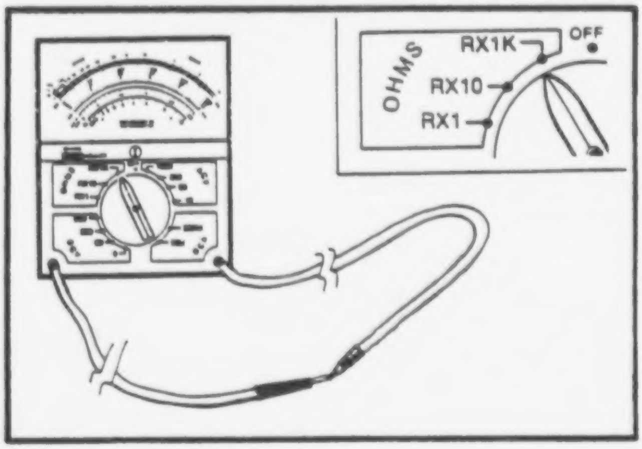


CAUTION: Never use a multimeter or ohmmeter on any circuit that has voltage present.

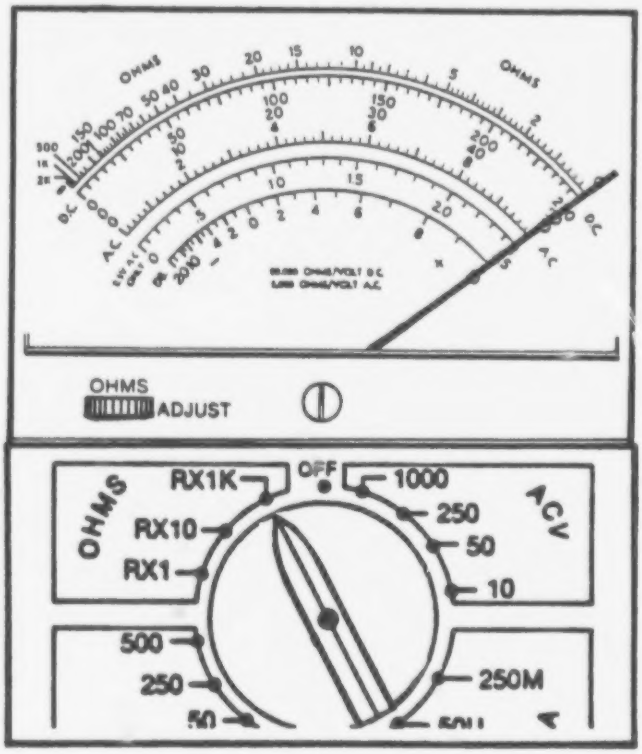
---

3. Place the range switch in the RX1K position.

4. Plug in the test leads. Short the leads by touching them together.



5. With leads touching (shorted) turn Ohms adjustment knob until the pointer rests at zero (0) on the ohms scale.

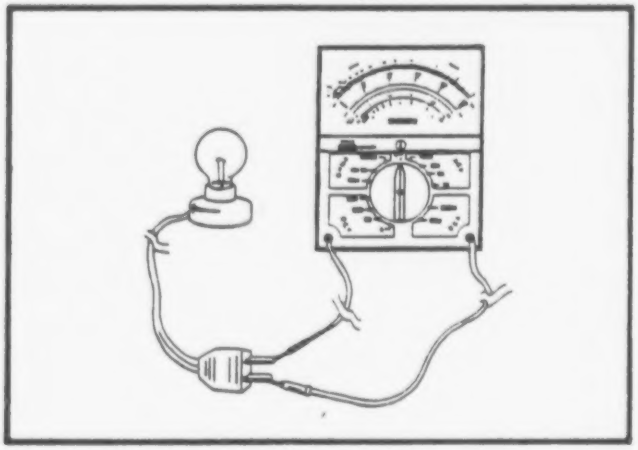

OHMS
OHMS
D.C.
A.C.
OHMS
ADJUST
OHMS
RX1K
OFF
1000
250
50
10
ACV
RX10
RX1
500
250
50
250M

6. Touch the leads to the circuit you want to measure resistance.

NOTE: When measuring resistance, one of the conductors running to the component must be removed to get a true reading.

---

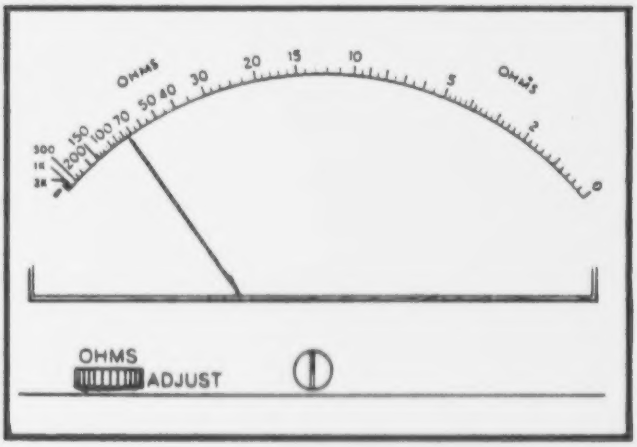
7. Locate the ohm scale on the meter and determine the pointer reading.



NOTE: If the pointer is between two numbers, add the smaller of the two numbers plus the number of marks that the pointer is past that smaller number.

---

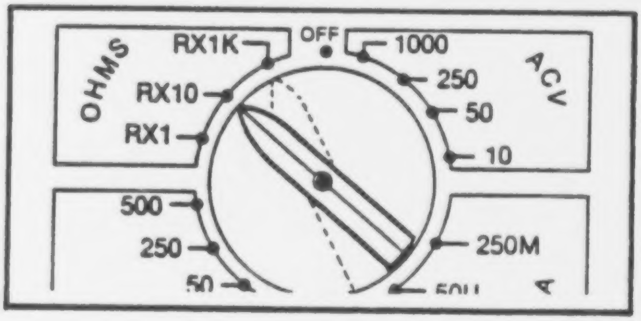
8. Adjust the range switch to keep the pointer reading on the right side of the scale so that the numbers will be easier to read. Try to keep the reading above two (2).


OHMS
300
1K
2K
200
150
100
70
50
40
30
20
15
10
5
OHMS
2
0
OHMS
ADJUST

Note: Each time the range switch is moved to another power on ohms, the meter must be "O'd out."

Reading the Ohm Scale:

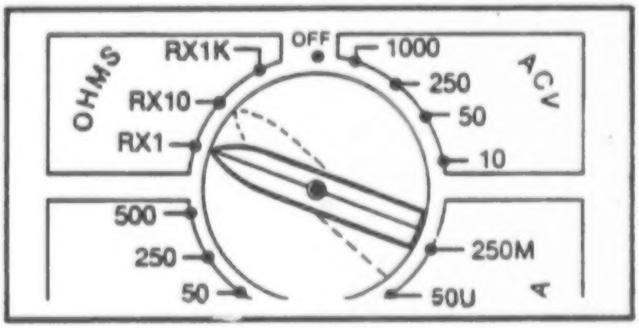
9. If the pointer shows a number larger than two, multiply that number by 1000 for the actual reading.


OHMS
RX1K
RX10
RX1
OFF
1000
250
50
10
ACV
500
250
50
250M
A

10. If the pointer shows a number smaller than two, turn the range switch from RX1K to RX10. Turn the ohms adjust knob until the pointer rests on zero (0). Then touch leads to the circuit (as you did earlier).

11. If the pointer shows a number larger than two, multiply the number by ten for the actual reading.

12. If the pointer still shows a number less than two, turn the range switch from RX10 to RX1. Turn the ohms adjust knob until pointer is at zero (0). Touch the test leads to the circuit again.

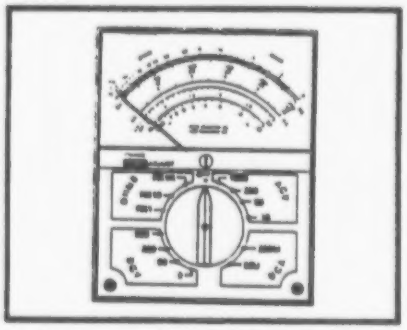

OHMS
RX1K
OFF
1000
ACV
RX10
250
50
RX1
10
500
250
250M
50
50U
A

13. The pointer reading this time shows the exact amount of resistance in ohms.

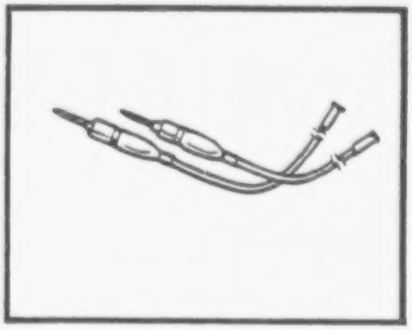
14. Turn the selector switch to off or any voltage or amp setting to avoid battery drain.

F. Steps of Procedure for Measuring Voltage with a Selector-Switch Multimeter

1. Assemble equipment and materials.

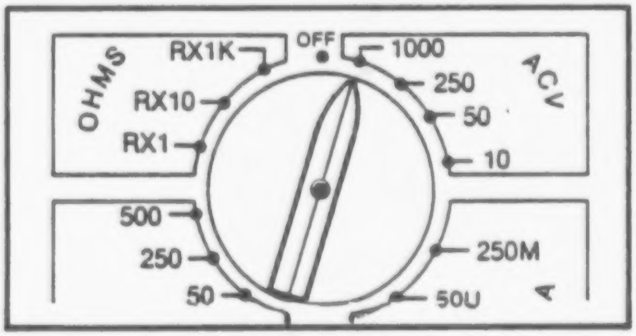


Selector-Switch Multimeter

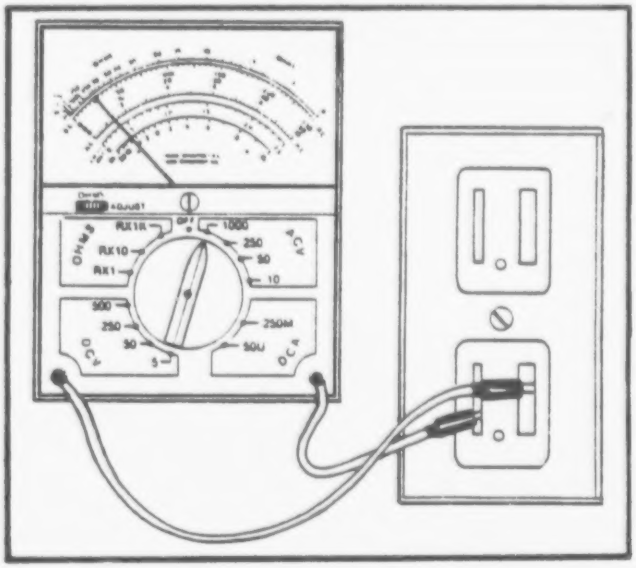


Test Leads

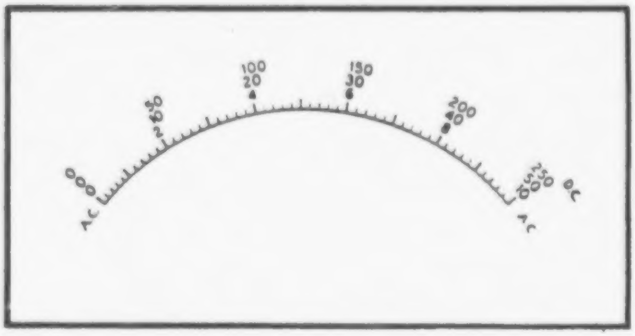
2. Plug the test leads into multimeter jacks. Turn the range switch to the highest ACV position (1000).


OHMS
RX1K
OFF
1000
ACV
RX10
250
50
RX1
10
500
250
50
250M
50U
A

3. Connect the test leads to the circuit where voltage is to be tested.



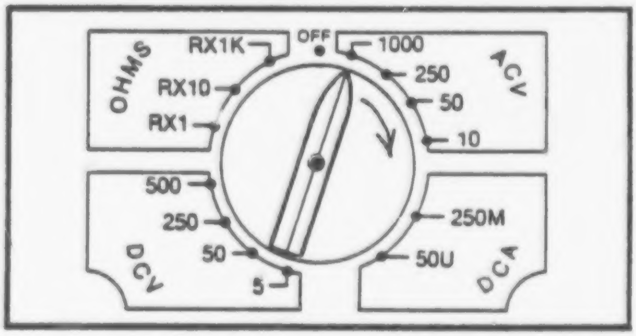
4. Locate the AC Volt (ACV) scale and mark the reading.



0 0 0
50 10 2
100 20 4
150 30 6
200 40 8
250 50 10
AC
DC
AC

NOTE: The ACV scale is actually three different scales:

0 to 250 - Top
0 to 50 - Middle
0 to 10 - Bottom
(If the meter can read 0 to 1000 volts, this scale is also read on the 0 to 10 scale.)

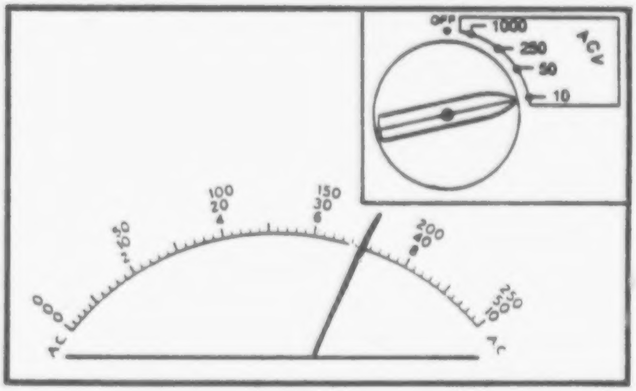


OHMS
RX1K
RX10
RX1
OFF
1000
250
50
10
ACV
500
250
50
5
DCV
250M
50U
DCA

5. If meter reading is lower than the next lower position of the range switch, turn the range switch to that next lower position.

Reading the Voltage Scale

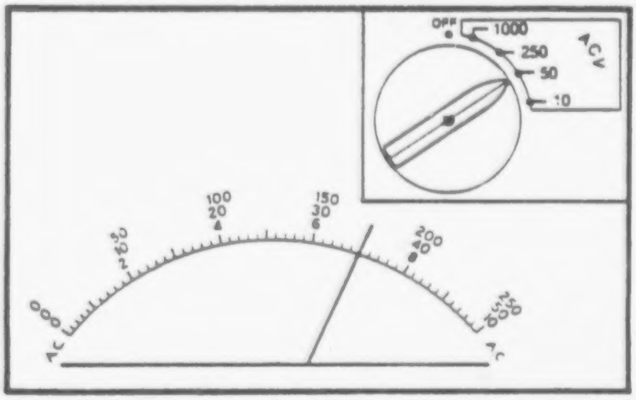
6. To measure voltage lower than 10 volts, turn the range switch to 10 on the ACV section and read on the 0 to 10 (bottom) scale.



OFF
1000
250
50
10
ACV
0 0 0
50 10 2
100 20 4
150 30 6
200 40 8
250 50 10
AC
AC

What is the voltage reading shown? __________

7. To measure voltage from 10 to 50 volts, turn the range switch to the 50 position on the ACV section and read on the 0 to 50 (center) scale.

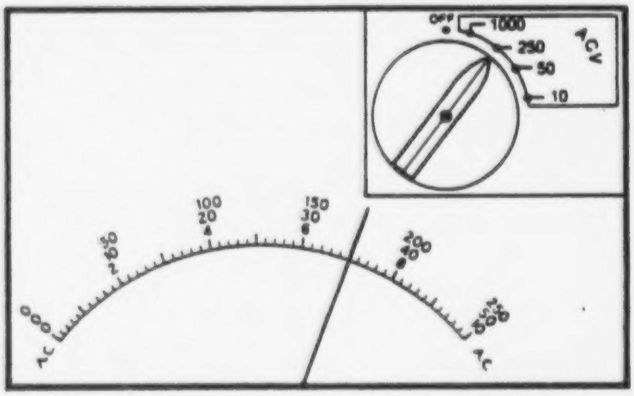


OFF
1000
250
50
10
ACV
0 0 0
50 10 2
100 20 4
150 30 6
200 40 8
250 50 10
AC
AC

What is the voltage reading shown? __________

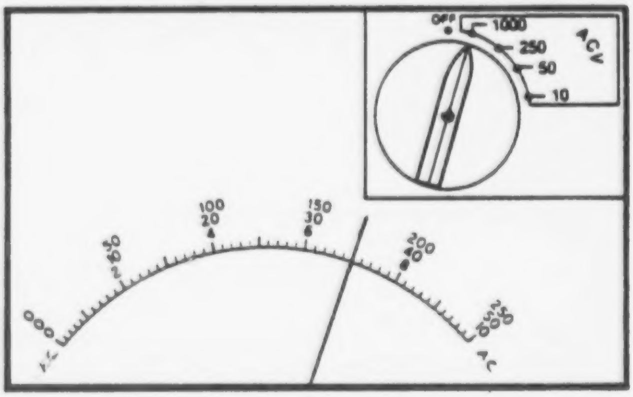
8. To measure voltage from 50 to 250 volts, turn the range switch to the 250 position on the ACV section and read the 0 to 250 (top) scale.

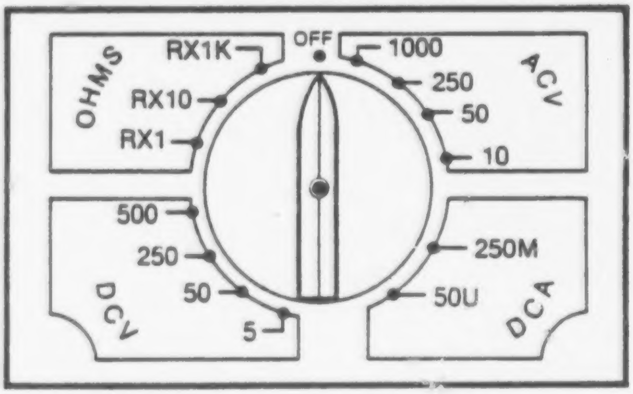
   What is the voltage reading shown? __________


OFF
1000
250
50
10
ACV
100
20
150
30
200
40
AC
AC

9. To measure voltage up to 1000 volts, turn the range switch to the 1000 position on the ACV section and read the (bottom) 0 to 10 scale. Put two zeros after the number to get the correct reading (a 7 would be 700 volts).

   What is the voltage reading shown? __________


OFF
1000
250
50
10
ACV
100
20
150
30
200
40
AC
AC


OHMS
RX1K
RX10
RX1
OFF
1000
250
50
10
ACV
500
250
50
5
DCV
250M
50U
DCA

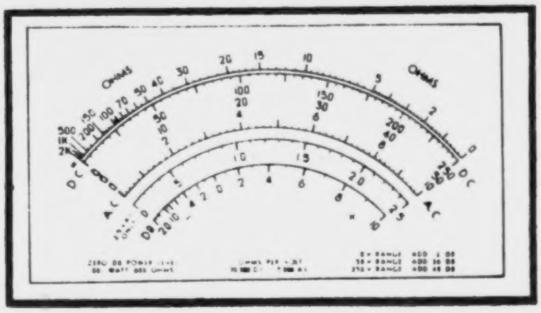
10. When finished with the multimeter, turn the range switch to the OFF position before storing the multimeter.

Do Skill Sheet 2
Do Activity Sheets 3 and 4.

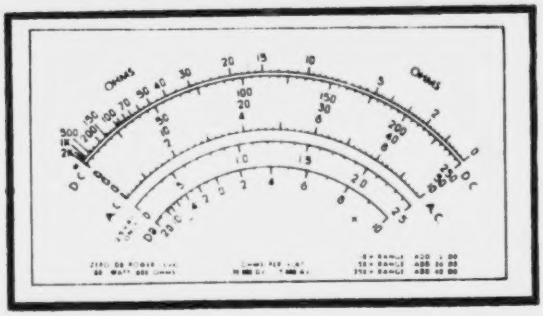
CURRENT, VOLTAGE, AND RESISTANCE
SKILL SHEET 2: READING OHMS ON SELECTOR-SWITCH MULTIMETER

Directions: Use a straight edge to draw in the pointer to show the following:

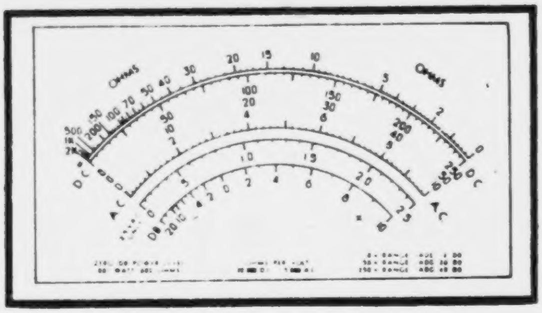
1. A reading of 12 ohms when range switch is at RX1.


OHMS
500
1K
2K
200
150
100
70
50
40
30
20
15
10
5
2
0
OHMS
DC
AC

2. A reading of 300 ohms when range switch is at RX10.


OHMS
500
1K
2K
200
150
100
70
50
40
30
20
15
10
5
2
0
OHMS
DC
AC

3. Show a short circuit reading.


OHMS
500
1K
2K
200
150
100
70
50
40
30
20
15
10
5
2
0
OHMS
DC
AC

CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 3: USE AN OHMMETER

Directions: Follow the steps below to use an ohmmeter.

1. Ask your instructor to watch you do this procedure.
2. Set up the meter to measure resistance as shown in the steps of procedure.
3. Measure the resistance of the 25 watt light bulb.
   Record your answer:________ ohms.
4. Measure the resistance of the 100 watt light bulb.
   Record your answer:________ ohms.
5. Check the two fuses for continuity as shown in the steps of procedure.

	Open	Short	Good	Bad
Fuse #1				
Fuse #2				

CURRENT, VOLTAGE, AND RESISTANCE
ACTIVITY SHEET 4: DEMONSTRATE KNOWLEDGE OF METERS

Directions: Follow the steps below to demonstrate your knowledge and understanding of meters.

1. Get one rotary scale clamp-on type meter and one line splitter.
2. Show them to your instructor. Name each part and tell what it does. Explain how to use the meter.
3. Get one selector switch multimeter.
4. Show it to your instructor. Name each part and tell what it is used for. Explain how to use the meter.

CURRENT, VOLTAGE, AND RESISTANCE

UNIT REVIEW

Directions: For each of the following questions, circle the best answer.

1. Electricity moving through a wire is called:_________

   a. Power
   b. Voltage
   c. Resistance
   d. Current

2. Electrical pressure that pushes the electricity through the wire is called:________________

   a. Power
   b. Voltage
   c. Resistance
   d. Current

3. The opposition to current flow is called:_________

   a. Power
   b. Voltage
   c. Resistance
   d. Current

4. The amount of current is measured in:

   a. Amps
   b. Volts
   c. Ohms
   d. Pounds

5. The amount of resistance is measured in:

   a. Amps
   b. Volts
   c. Ohms
   d. Pounds

6. When measuring resistance, the power must be turned on.

   True or False

7. When checking a circuit for continuity, the power must be turned off.

   True or False

8. A short circuit has very little or no resistance.

   True or False

9. A clamp-on type meter only works with alternating current.

   True or False

10. An open circuit is shown by a reading of zero (0) on the ohms scale.

   True or False

CURRENT, VOLTAGE, AND RESISTANCE PERFORMANCE CHECKLIST

Student ________________ has successfully performed the following steps of procedure.

	Yes	No	Comments
1. Measured current with a clamp-on meter			
2. Measured voltage with a clamp-on meter			
3. Measured resistance with a clamp-on meter			
4. Measured resistance (ohms) with a selector-switch multimeter			
5. Read the ohm scale			
6. Measured voltage with a selector-switch multimeter			
7. Read the voltage scale			

Satisfactory - Should Move On ___

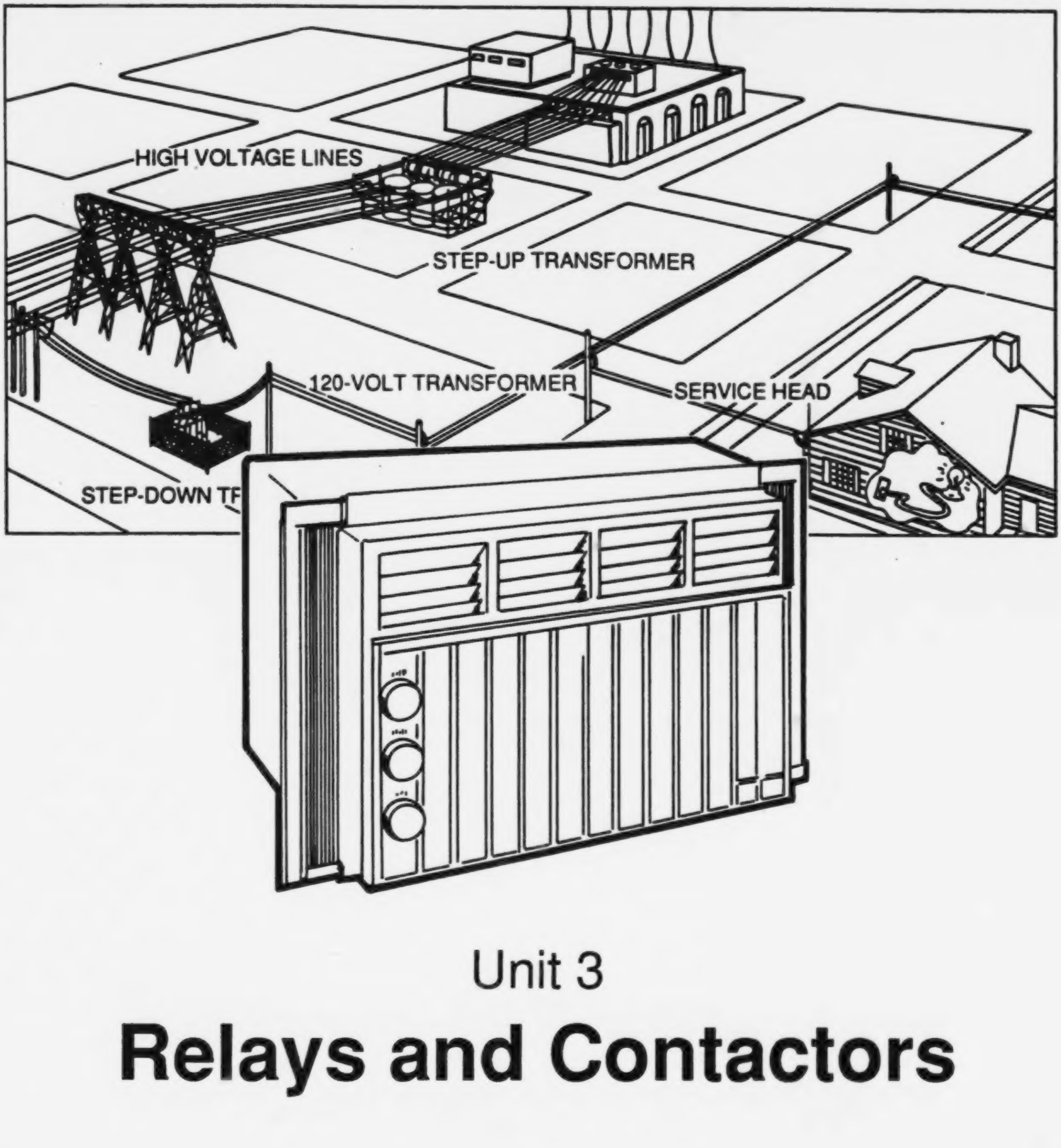
Repeat This Unit ___

Student's Signature/Date

Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 3

Relays and Contactors

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

RELAYS AND CONTACTORS

INTRODUCTION

A relay is a switch operated by an electromagnet. Relays are used to remove the starting circuit from operation when the motor reaches approximately 75 percent of its normal running speed. Contactors are a larger type of relay switch and are used for heavy duty operations. Relays are used in electrical circuits on air conditioning and refrigerating equipment. Types of relays often used are fan relays, motor starting relays, and main power line relays. Relays are usually replaced rather than repaired. A service technician must know how to tell if a relay is defective and how to replace it. He/she must also know how to test and repair contactors.

Unit Objectives

After completing this unit, you should be able to tell if a relay or contactor is defective, replace a relay, and repair a contactor.

Specific Objectives

After completing this unit, you should be able to specifically:

1. Identify current relays, potential relays, and control relays.
2. Test current relays, potential relays, and control relays.
3. Replace current relays, potential relays, and control relays.
4. Inspect and test a contactor.
5. Repair a contactor, including coil replacement and contact replacement.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

Terms

1. Armature - the moving part of a relay or contactor.
2. Capacitor - a device that stores electricity. Capacitors are used to help start motors, increase their efficiency, and improve the power factor.
3. Circuit - a path which permits the flow of electric current.
4. Conductor - something which can carry electricity; for example, iron is a conductor because electricity can flow through iron.
5. Contact - a connection between two conductors in a circuit or the device that opens and closes this connection.
6. Contactor - a magnetic relay switch. A contactor is larger than a relay and is used for heavy duty operations in which larger amounts of current are interrupted.
7. De-energize - to stop the flow of electric current to a circuit or system of conductors.
8. Electromagnet - a piece of soft iron surrounded by a coil of wire that temporarily becomes a magnet when an electric current flows through the wire.
9. Energize - to start the flow of electric current to a circuit or system of conductors.
10. NC - normally closed.
11. NO - normally open.

12. Normally closed - contacts that are closed when the relay coil is de-energized and open when power (current) is supplied to the relay coil.

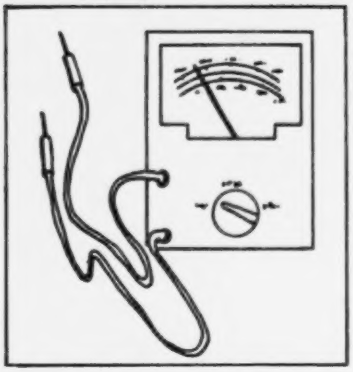
13. Normally open - contacts that are open when the relay coil is de-energized and close when power (current) is supplied to the relay coil.

14. Relay - an electromagnetic switch that opens or closes contacts in an operating circuit.

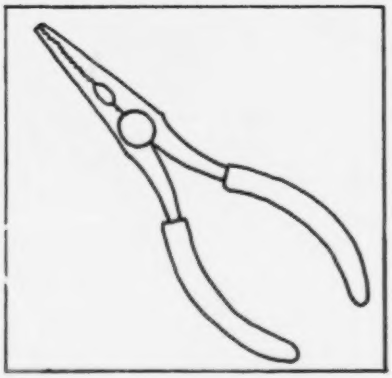
15. Relay coil - a spiral or loop of wire (or other conducting element) in a relay used as an inductor.

16. Terminal - a connective device or point on an electric circuit or conductor.

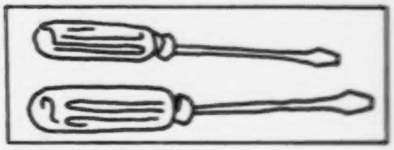
Equipment



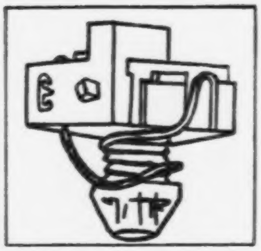
MULTIMETER



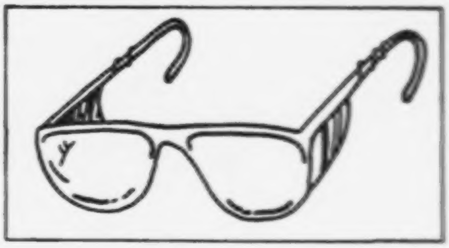
INSULATED
LONG-NOSE
PLIERS



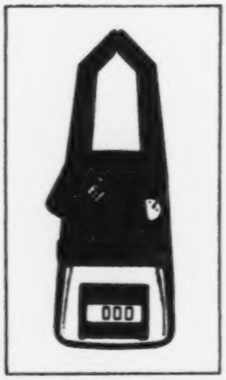
STANDARD
SCREWDRIVERS



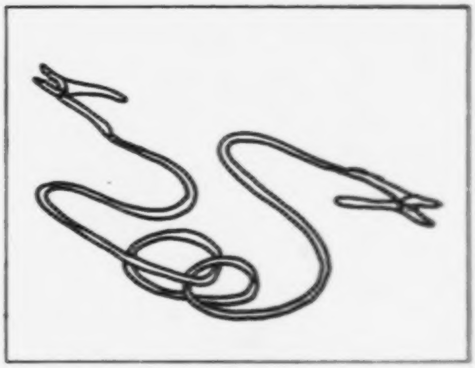
CURRENT RELAY



SAFETY GLASSES



DIGITAL
VOLTMETER



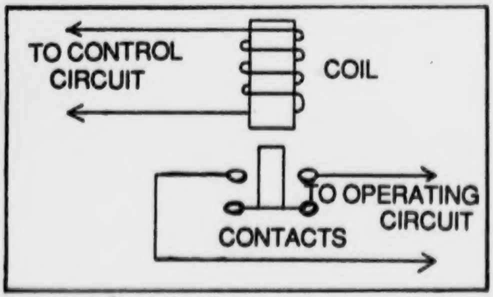
JUMPER WIRE
WITH INSULATED
ALLIGATOR CLIPS

B. Understanding How Relays and Contactors Work

Most relays contain coils of wire. Any coil of wire will act like an electromagnet whenever electric current flows through the coil. Relays also contain contacts that control current flow by opening to stop the current flow or closing to allow current flow.

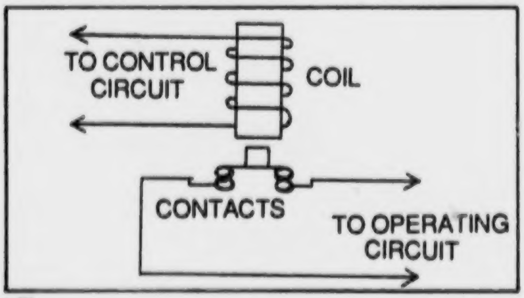
The most common types of relays use gravity or a spring to hold the contacts in their normal position. The electromagnet is used to change the position of the contacts.

A relay can have any number of contacts. Each set of contacts forms a path for the flow of current and is called a pole. A simple relay is shown in Figure 1. A & B.



1A

Relay with normally open contacts. (NOTE: The contacts will close when the relay coil is energized.)



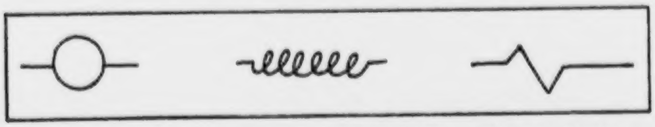
1B

Relay with normally closed contacts. (NOTE: The contacts will open when the relay coil is energized.)

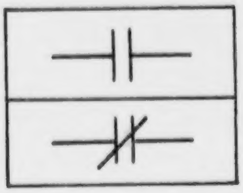
The relays and contactors described in this unit are typical of the most common ones used in air conditioning and refrigeration. Differences do exist from one model to another and between different manufacturers, but they all work in basically the same way.

In explaining the operation of relays, drawings of the electrical connections are used. The following symbols are used for relays and contactors.

RELAY OR CONTACTOR COIL



RELAY OR CONTACTOR CONTACTS



Contacts normally open

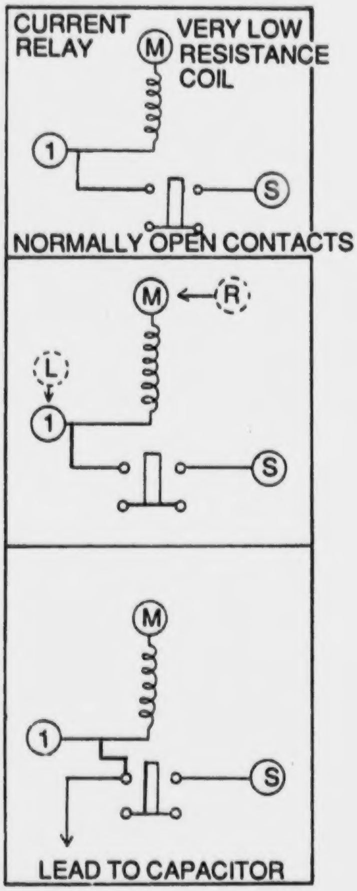
Contacts normally closed

C. Steps of Procedure for Identifying, Testing, and Replacing Current Relays

NOTE: Current relays are used as motor starting relays on smaller size hermetic motors used on household refrigerators and freezers.

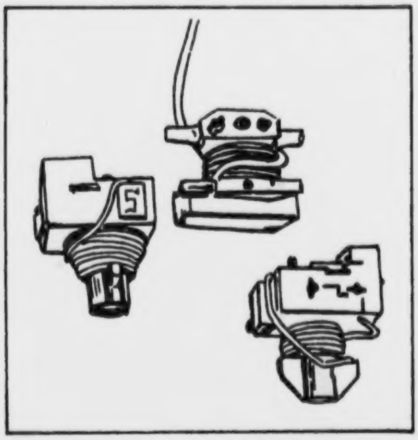
CURRENT RELAY INFORMATION

1. For identification and testing you should know how a current relay is connected electrically and what the terminal markings are.
2. A very low resistance coil is connected between terminals "M" and "1." A set of normally open contacts are connected between terminals "1" and "S." The contacts are held open by gravity.
3. On some relays, the "M" terminal may be marked "R" and the "1" terminal marked "L."
4. On some relays used with a capacitor start motor, a fourth terminal for the capacitor is used.



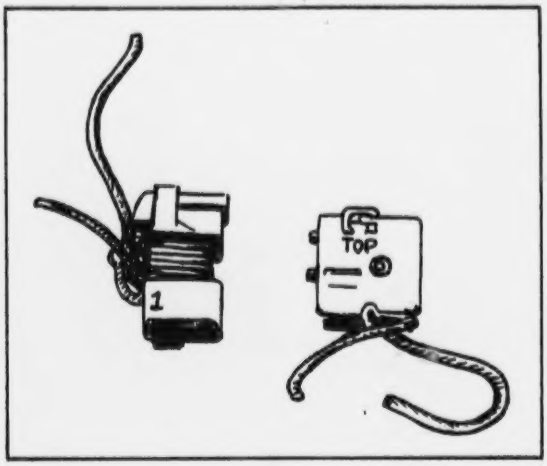
IDENTIFICATION

1. Current relays can be identified by sight. The coil of wire will be visible. The relay will have two pin connector terminals and one or two standard terminals. Some current relays will have two wire connectors instead of pin terminals.



2. Visual markings that help in identification

    - The top is usually marked.
    - One pin terminal is marked "S" and the other is marked "M" or "R."
    - The terminal connector to the source of power is marked "1" or "L."



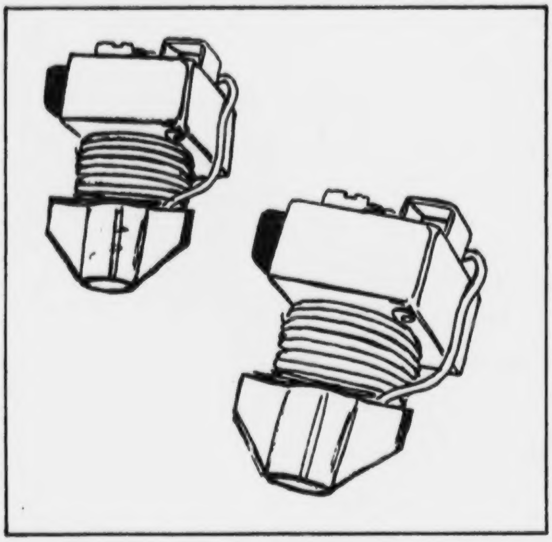
3. Most current start relays look alike even though some differences exist between models and manufacturers.

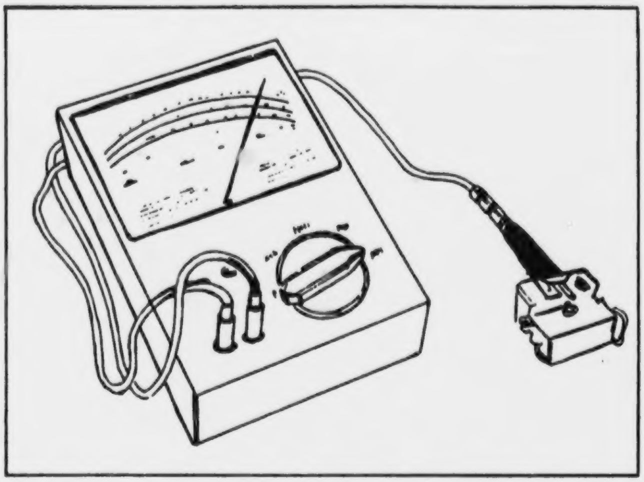
TESTING

1. **The Substitute Test**
   One sure way to test any relay is the substitute test.

   Take the relay in question and temporarily replace it with one you know is good. The replacement relay must be the exact same type, size, and rating.

   If the equipment works with the new relay, the old one was bad. If the equipment does not work, there is another problem.

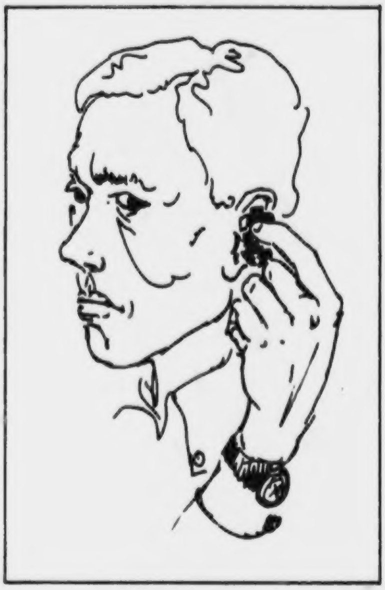




2. The relay can also be tested with an ohmmeter.

   - With the relay right side up, the reading from "1" to "S" should be infinity (∞) and from "1" to "M" should read less than one ohm.

   - Turn the relay upside down and read from "1" to "S." The reading should be less than one ohm.

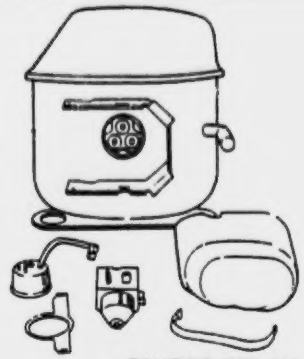


   - Put the relay to your ear and very gently shake the relay. You should hear a rattle.

   NOTE: If you do not get the readings called for in steps 1 and 2, or you cannot hear a rattle, the relay should be replaced.

INSTALLING/REPLACING

Current relays will be located on the side of hermetic motors under a plastic cover. The relay is made so it will pull off or push on the motor terminal pins.

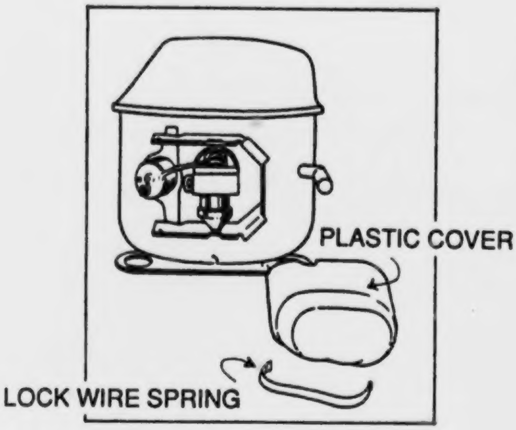


ON/OFF RELAY
PUSH-ON

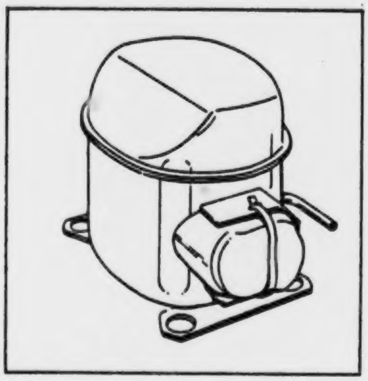
CAUTION: TURN POWER OFF.

1. Remove the lock wire spring and plastic cover.
2. Remove the lead from the relay terminal.
3. Pull the old relay off the compressor motor pin terminals.

   NOTE: The new replacement relay must be the exact same type, size, and rating.



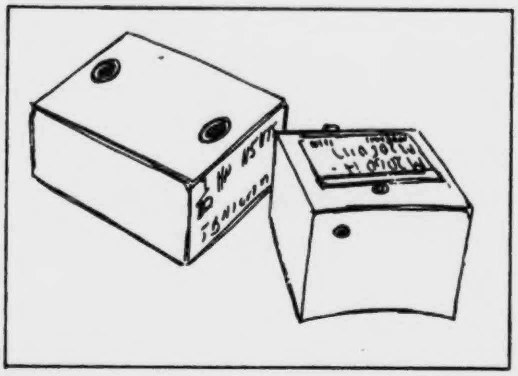
4. Push the new relay onto the compressor motor pin terminals. Be sure the relay is right side up.
5. Replace lead on terminal.
6. Replace plastic cover and lock wire spring.



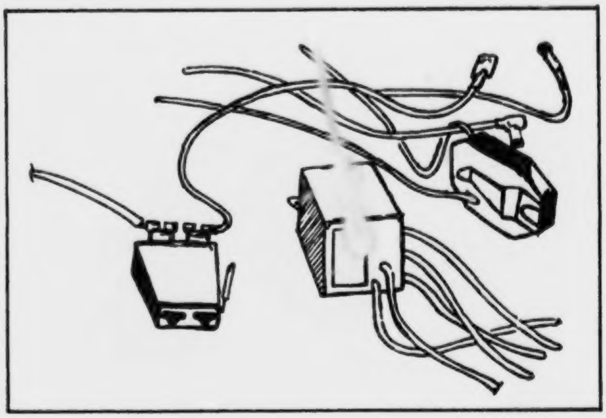
OTHER TYPES OF CURRENT RELAYS

1. We have been studying the magnetic, open coil type relay. Other less common types of current relays do exist.

   They can be tested by the substitution method described earlier.



2. Solid state relays may be available. Any current relay may be replaced with a solid state relay.



3. Solid state relays are matched to motor horse power and voltage.

   Some solid state relays include overload protection to replace the hot wire relay/overload.

   Step-by-step instructions for using solid state relays come with each relay.

DO ACTIVITY SHEET 1.

RELAYS AND CONTACTORS
ACTIVITY SHEET 1

1. Use an ohmmeter to check a current relay.

   a) With the relay right side up reading from "M" to "1" is ________________ ohms.

   b) Reading from "S" to "1" is _________ ohms.

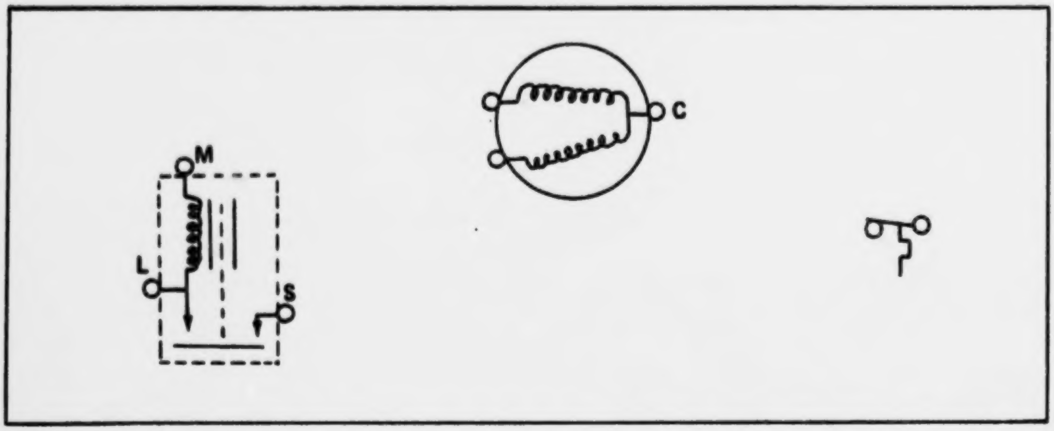
   c) With the relay upside down reading from "S" to "1" is ________________ ohms.

   If you shake the relay, can you hear a rattle?

   YES ___ NO ___

   This relay is good ___ bad ___

2. Draw the electrical connection for a current relay.



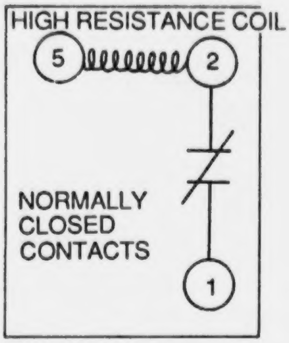
D. Steps of Procedure for Identifying, Testing, and Replacing Potential Relays

NOTE: Potential relays are used for motor starting relays on larger capacitor start - capacitor run hermetic motors.

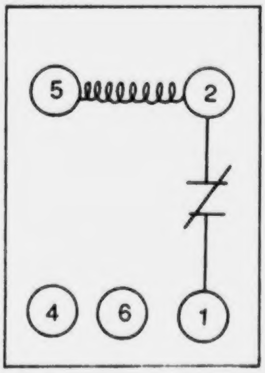
Potential Relay Information

1. For identification and testing, you should know how a potential relay is connected electrically and what the terminal markings are.

2. A high resistance coil is connected between terminals "5" and "2." A set of normally closed contacts is connected between terminals "2" and "1."

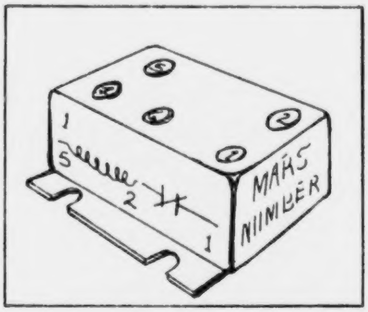


   Two other terminals marked "4" and "6" are provided as a connection point for other components. Terminals "4" and "6" are not electrically connected to the relay.



Identification

Potential relays can be identified by terminal markings 1 to 6 with number 3. The relay may also have a circuit diagram on the side.

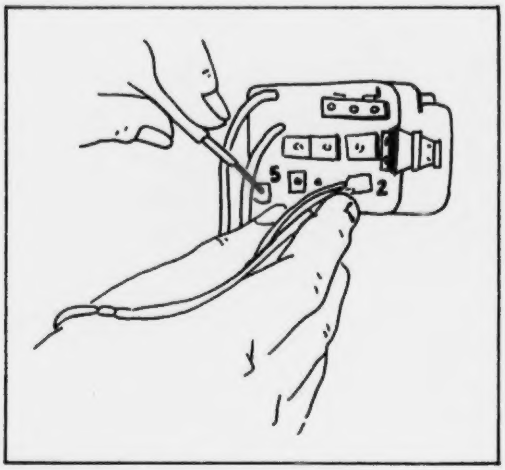


Testing

One way to test a potential relay is the substitute test (explained earlier).

Here is another way to test a potential relay.

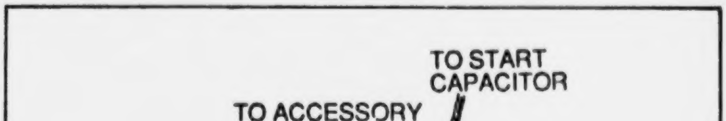
CAUTION: TURN POWER OFF.



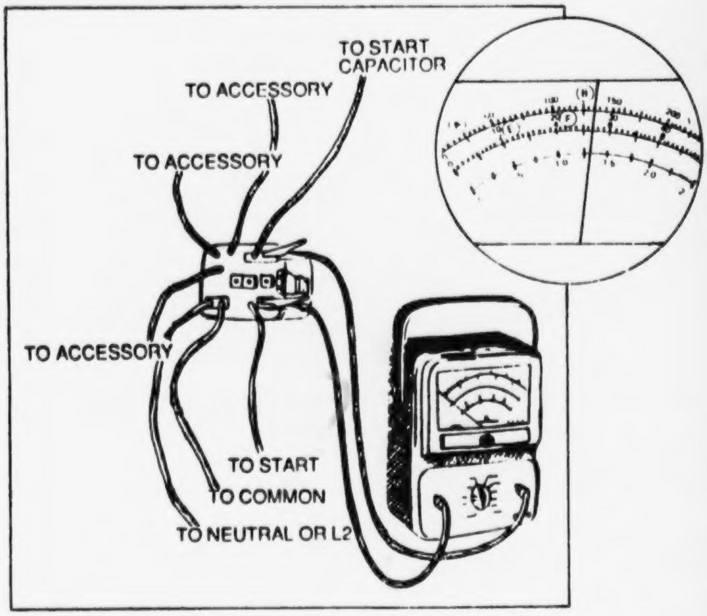
1. Be sure capacitor has been discharged. Remove leads from terminals 1 and 5.
2. Measure resistance between these two terminals. If the reading is 5,000 to 6,000 ohms, the relay is good.
3. Securely replace all leads removed.
4. If no reading is indicated, the relay is faulty. Replace it.

CAUTION: MAKE SURE POWER IS OFF.

5. With power off and using a multimeter in the voltage mode, connect one alligator clip tip probe to terminal 1. Attach the other alligator clip tip probe to terminal 2.



Watching the meter, turn the power back on. If voltage is read on the meter, the contacts are opening; the problem is elsewhere. If no voltage is read, the contacts are not opening. Replace the relay.


TO START CAPACITOR
TO ACCESSORY
TO ACCESSORY
TO ACCESSORY
TO START
TO COMMON
TO NEUTRAL OR L2

NOTE: This relay is usually positional. Make sure the relay is in its operational position when the test is run.

Installing/Replacing

CAUTION: TURN POWER OFF. CHECK EQUIPMENT DEENERGIZED WITH A VOLTMETER.

1. Potential relays are used on some large window air conditioners and on some control air conditioners.

2. The potential relay will be located near the compressor or in the control section of the window air conditioner on the condensing unit.

   NOTE: Replacement relays must be the exact same size, type, and rating as the one being replaced.

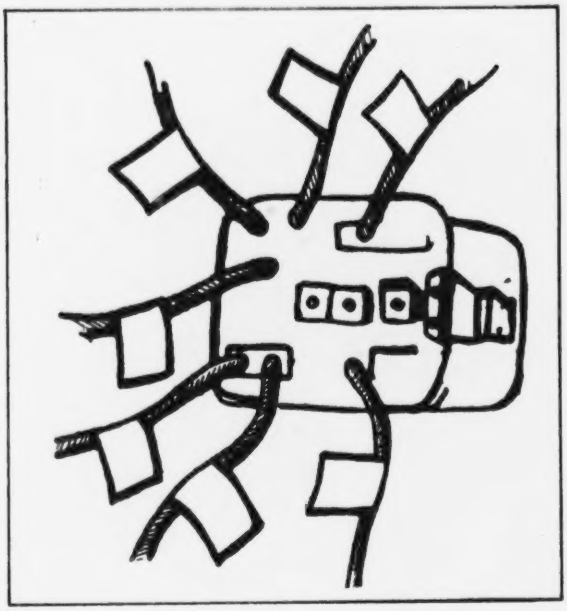
4. Using tape or other markers, mark each lead going to the relay as the lead is removed.

   EXAMPLE: If lead goes to terminal 4, mark the lead "4."

5. Mount new relay in same position as old one.

6. Reconnect all leads to the relay.

   CAUTION: TAKE CARE TO BE SURE LEADS ARE CONNECTED TO PROPER TERMINALS.



DO ACTIVITY SHEET 2.

RELAYS AND CONTACTORS

ACTIVITY SHEET 2

1. Use an ohmmeter to check a potential relay.

   Reading from 1 to 5 is _________ ohms.

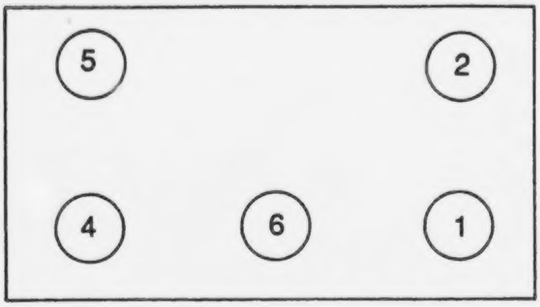
   This relay is ___ unknown
   ___ good
   ___ bad

2. How could you tell if contacts between 1 and 2 are stuck or welded shut?

   ____

   ____

3. Draw the electrical connections for the potential relay shown below.



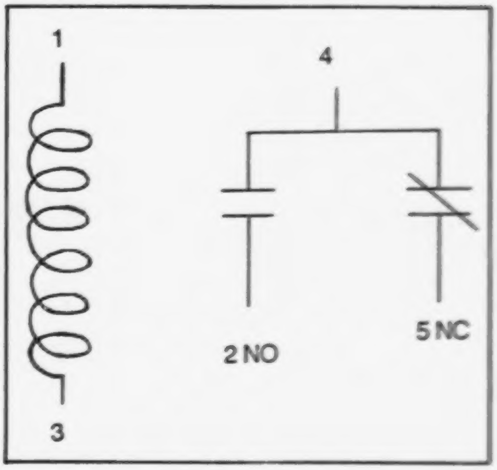
E. Steps of Procedure for Identifying, Testing, and Replacing Control Relays

CONTROL RELAY INFORMATION

Control relays are used when a low voltage control circuit is used to control fans and motors in the higher voltage operating circuit.

IDENTIFICATION

Control relays have the coil voltage rating marked on the relay (usually 24 volts). Many relays have a circuit diagram showing how the relay is connected. Many also have a circuit diagram showing how it is connected in the circuit.



NOTE: The diagram shows a relay with a coil between terminals 1 and 3, a set of normally open contacts between terminals 4 and 2, and a set of normally closed contacts between terminals 4 and 5. With this relay, when the coil is energized, both switches change position. The NO (normally open) will close and the NC (normally closed) will open.

TESTING

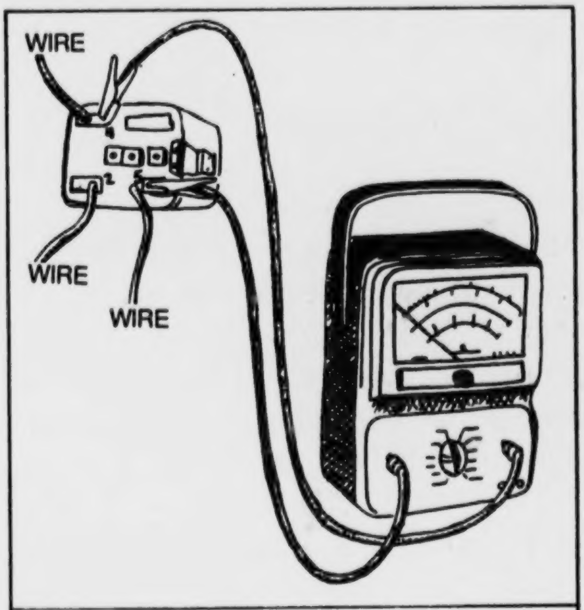
1. The substitution test explained earlier is one method of testing control relays.

2. Another way to test a relay is to check its contact operation.

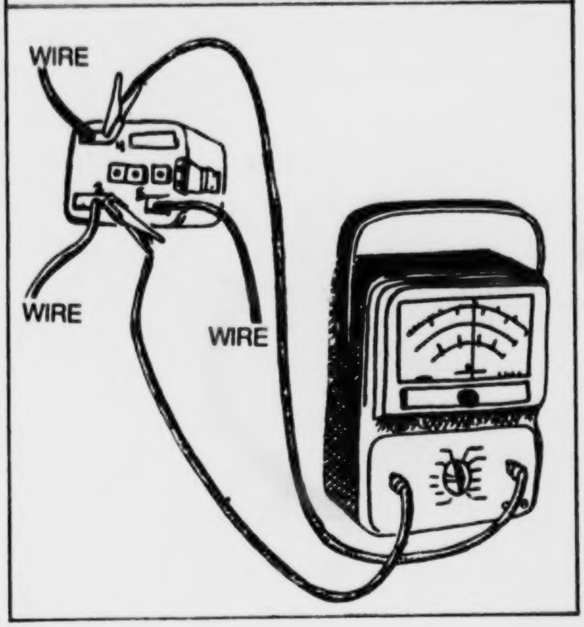
CAUTION: YOU WILL BE WORKING ON AN ENERGIZED CIRCUIT. FOLLOW SAFETY PRECAUTIONS. USE INSULATED RUBBER GLOVES.

WITH SYSTEM DISCONNECTED

- To check that normally open contacts have closed, use a multimeter with alligator clip probes. With clips attached across contacts, and the meter turned to the proper voltage setting, apply voltage to the system. If the meter needle remains on "O," the switch has closed. If the meter reads voltage (for example, 120 volt), it is faulty.



- To check if normally closed contacts have opened, the same procedure as above is used. If the contacts have opened, the meter will read the voltage. If closed, no voltage will be read.



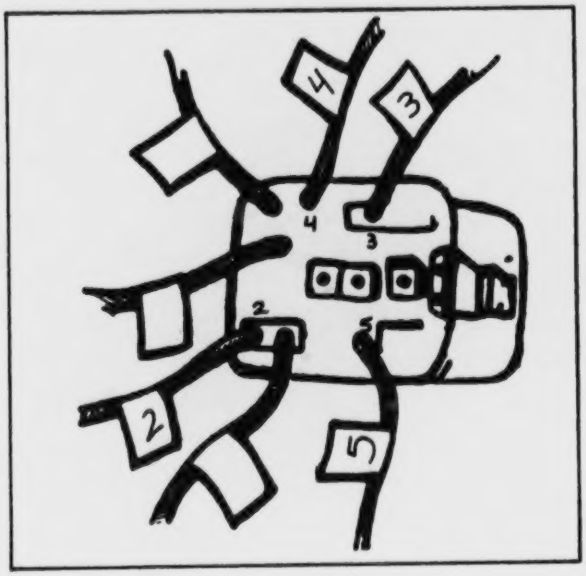
- Any relay found to be bad must be replaced. Relays cannot be repaired.

INSTALLING/REPLACING

CAUTION: TURN OFF POWER TO THE EQUIPMENT. CHECK EQUIPMENT DEENGERGIZED WITH A VOLTMETER TO MAKE CERTAIN THAT ALL POWER HAS BEEN TURNED OFF.

1. Using masking tape or other markers, mark each lead going to the relay as the lead is removed.

   EXAMPLE: If lead is going to terminal 3, mark the lead "3."



2. Mount the new relay in the same position as the old one.

3. Reconnect all leads to the relay.

   CAUTION: TAKE CARE TO BE SURE LEADS ARE CONNECTED TO PROPER TERMINALS.

DO ACTIVITY SHEET 3.

RELAYS AND CONTACTORS

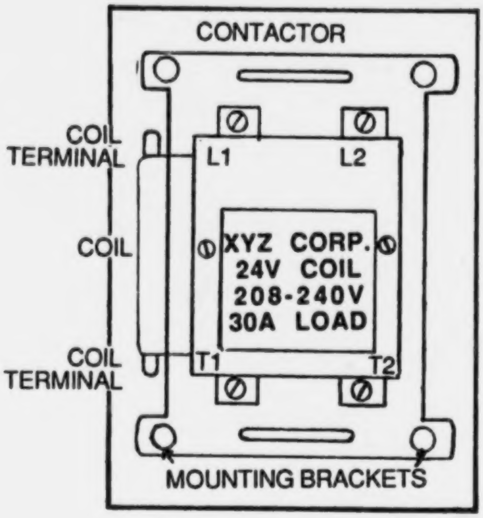
ACTIVITY SHEET 3

Check a control relay with an ohmmeter and answer the following questions.

1. What is the resistance of the coil? ________ ohms
2. How many normally open contacts does this relay have?
   ____
3. How many normally closed contacts does this relay have?
   ____
4. Draw a picture showing the electrical connections in this relay.

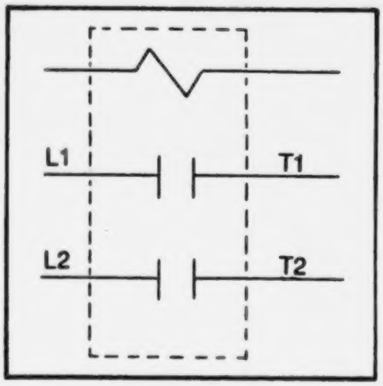
F. STEPS OF PROCEDURE FOR INSPECTING, TESTING, AND REPAIRING CONTACTORS

Contactor Information

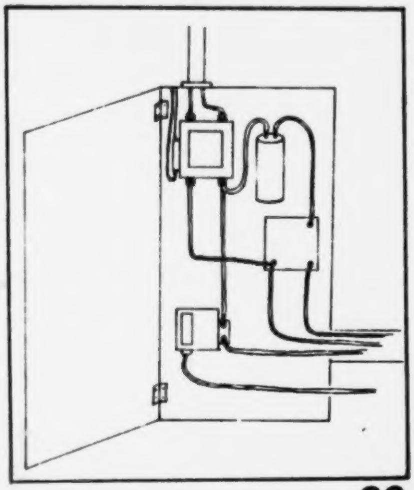

CONTACTOR
COIL TERMINAL
L1
L2
COIL
XYZ CORP.
24V COIL
208-240V
30A LOAD
COIL TERMINAL
T1
T2
MOUNTING BRACKETS

1. Contactors are large relays able to control higher currents than standard relays. They are used in central air conditioning and heat pump control circuits.

   Contactors are also used in commercial refrigeration and all large motor control circuits.



2. Contactors are used as main line switches. Contactor electrical connections are shown in this diagram. Power leads going into the contactor are marked L1 and L2. Power leads coming out of the contactor and going to the motor or compressor are marked T1 and T2.



3. Contactors are located in the electrical section of the heat pump or air conditioning outdoor condensing unit. To get at the contactor, the access panels must be removed.

Inspection of Contactors

1. **TURN OFF POWER.**

2. Remove access panels.

3. **TEST CIRCUITS TO BE SURE THEY ARE DEENERGIZED.**

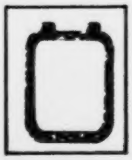
4. Check for visual signs of problems, such as:

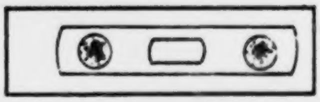
   - Loose connections

   - Charred coil

   - Charred or burnt leads

   - Pitted contacts



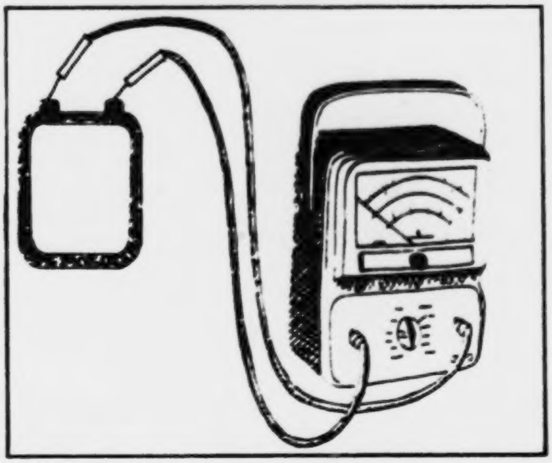


5. Check that the armature is free to move and that contacts return to open position.

6. Check coil with ohmmeter for:

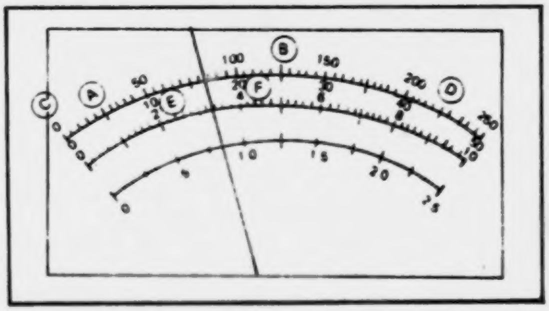
   - Continuity

   - Shorts



7. If inspection shows the contactor to be bad, repair or replace as required.

8. If inspection shows no problems, go to section on testing.



TESTING CONTACTORS

After inspection and coil continuity check are completed. Turn the power on.

CAUTION: YOU WILL BE WORKING ON ENERGIZED CIRCUITS. FOLLOW ALL SAFETY PRECAUTIONS.

1. Make a voltage check at contactor coil leads.
    - No voltage at coil leads: The contactor is good, but there is a problem in the control circuit.
    - Voltage at coil leads: Continue testing at step 2.
2. Make a voltage check between input leads L1 and L2.
    - No voltage reading between L1 and L2: Contactor is good. The problem is with the power supply fuse or circuit breaker.
    - Voltage at L1 and L2: Continue testing at step 3.
3. Make a voltage check between output leads T1 and T2.
    - No voltage at T1 and T2: Contactor is bad.
    - Voltage at T1 and T2: Continue testing step 4.

4. Make a voltage check from L1 to T1 and from L2 to T2.

   - Any voltage (even the smallest amount) from L1 to T1 or L2 to T2: The contactor is bad.

   - No voltage from L1 to T1 and L2 to T2 and with full line voltage present at T1 and T2 in step 3: The contactor is good but there is a problem in the equipment motor circuit.

   NOTE: If inspection and testing indicate a bad contactor, the contactor must be repaired or replaced. Some small contactors cannot be repaired and must be replaced. Larger contactors can usually be repaired.

Repairing Contactors

CAUTION: TURN POWER OFF. TEST CIRCUITS TO BE SURE THEY ARE DEENERGIZED.

If continuity check and inspection show the coil to be open, shorted, or burnt, the coil may be replaced using a coil of the same type, size, and rating.

Replacement of Complete Contactor

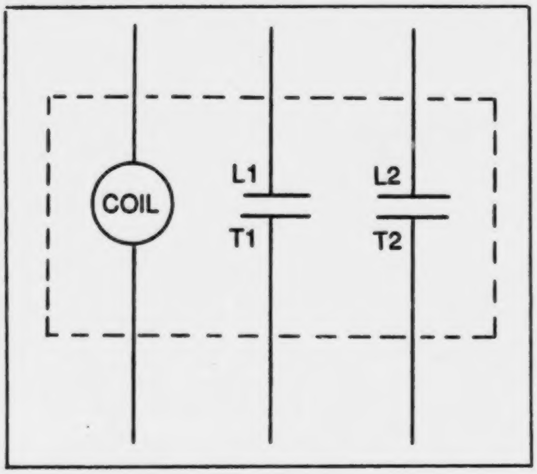
On residential equipment, contactors can be repaired. However, because of the cost of time and materials, contactors are simply replaced. To replace a contactor, proceed as follows.

1. **USE A VOLTMETER TO CHECK THE CIRCUIT DEENERGIZATION.**

2. Remove contactor from the cabinet by loosening screws on mounting bracket and lifting out.

3. Using tape or other markers, number and mark all leads.

4. Make a drawing of how leads are connected to contactor.



5. Remove leads from old contactor and reconnect to replacement contactor, using your drawing as a guide.

RELAYS AND CONTACTORS

UNIT REVIEW

1. A current relay has contacts that are

   a) N.O.
   b) N.C.
   c) Mixed
   d) Fixed

2. A potential relay has contacts that are

   a) N.O.
   b) N.C.
   c) Mixed
   d) Fixed

3. A relay is an electrically operated

   a) Pole
   b) Control
   c) Switch
   d) Transformer

4. A contactor is a large

   a) Relay
   b) Transformer
   c) Control
   d) Load

5. In a relay each path of current through the contacts is called a

   a) Load
   b) Control
   c) Transformer
   d) Pole

6. The coil of a current relay has low resistance.
   True or False

7. The coil of a potential relay has low resistance.
   True or False

8. Solid state relays are commonly used to replace current relays.
   True or False

9. A type of relay used to start larger hermetic motors is a
   __________________ relay.

10. A type of relay used to start smaller hermetic motors is a
    __________________ relay.

RELAYS AND CONTACTORS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Identify current relays, potential relays, and control relays.			
2. Test current relays, potential relays, and control relays.			
3. Replace current relays, potential relays, and control relays.			
4. Inspect and test a contactor.			
5. Repair a contactor, including coil replacement and contact replacement.			

Satisfactory - Should Move On ☐

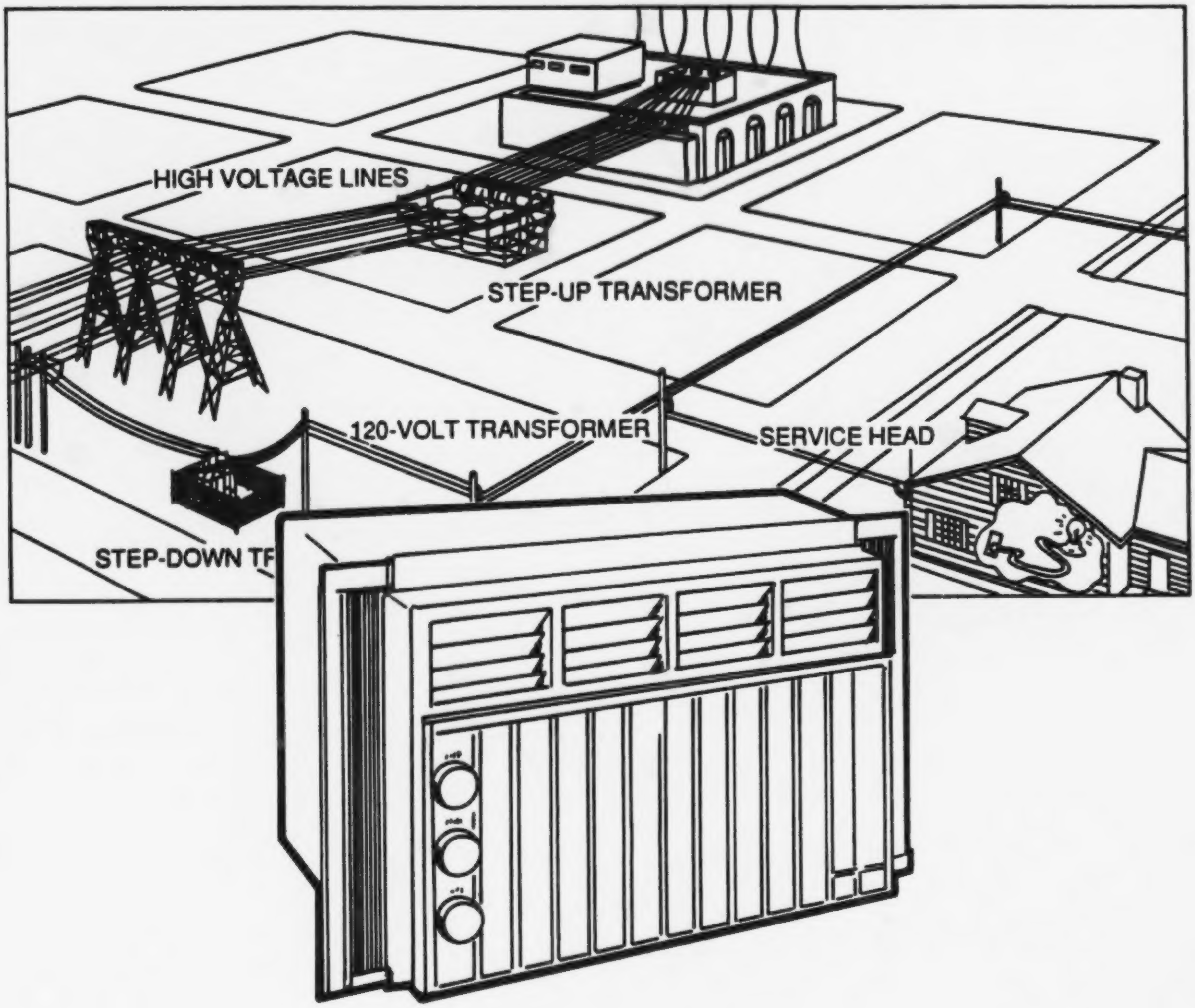
Repeat This Unit ☐

____
Student's Signature/Date

____
Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 4

Electric Motors

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

ELECTRIC MOTORS

INTRODUCTION

There are many types of electric motors. This unit covers the types of motors used in domestic refrigeration units and window air conditioners.

Before beginning this unit of instruction, you should have completed the following units:

1. Safety
2. Current, Voltage, and Resistance
3. Relays and Contactors
4. Electrical Components

UNIT OBJECTIVE

After completing this unit, you should be able to identify, troubleshoot, and maintain the types of motors used for domestic refrigeration units and window air conditioners.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to:

1. Disassemble, inspect, clean and reassemble a double-shaft fan motor.
2. Identify hermetic compressor motors and terminals.
3. Test motor capacitors.
4. Test a hermetic motor for faults in the windings.
5. Operate a hermetic motor on a test cord.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

➜ **SEE YOUR INSTRUCTOR**

☐ **I want to study the information in this unit before I do the Performance Checklist.**

➜ **TURN PAGE AND BEGIN**

A. Terms and Equipment

Terms

1. Atmosphere - the air; gases in the air. Atmospheric pressure is the pressure or force applied by gases in the air.

2. Disassemble - to take something apart.

3. Domestic refrigeration units - refrigerators and freezers made for household use.

4. Hermetic - airtight, completely sealed in order to keep air or gas from getting in or out.

5. Hermetic refrigeration system - the compressor is driven by a motor contained in a sealed dome or housing with the compressor. The motor operates in an atmosphere of the refrigerant.

6. Open refrigeration system - the compressor is belt-driven from an electric motor. This system requires a crankshaft seal on the compressor. The motor and the compressor drive are at atmospheric pressure. Also called external drive system.

7. Reassemble - to put something back together.

8. Schematic diagram - a diagram, or drawing, of electrical wiring in a circuit.

9. Shaded-pole motor - a small motor designed to start under light loads.

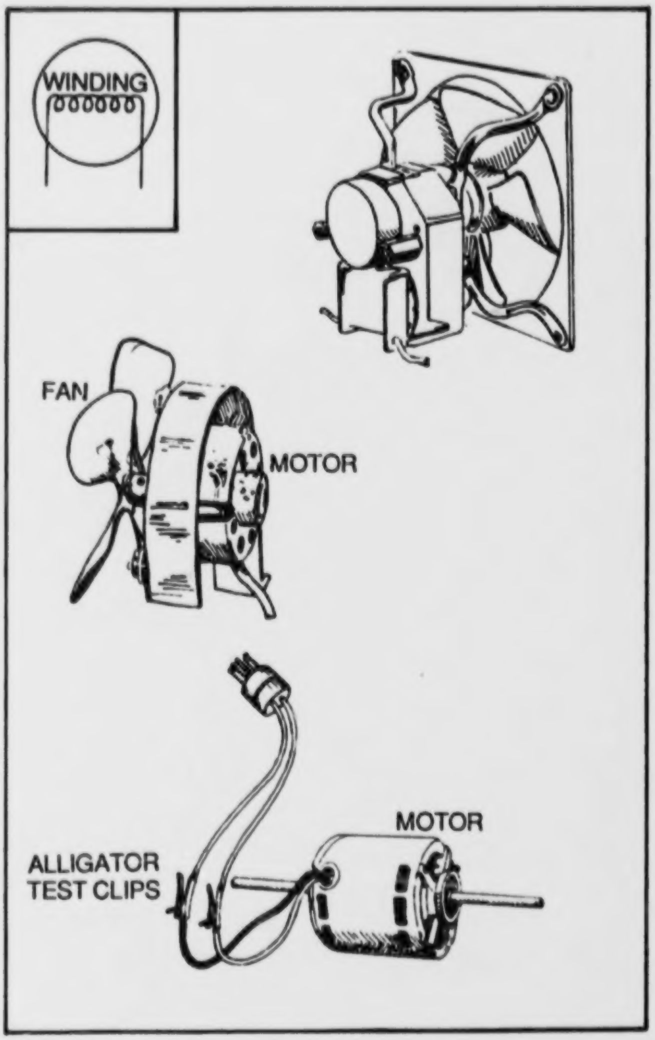
10. Torque - turning or twisting force.

11. Windings - coils of wire through which electric current flows (the main part of a motor).

B. Types of Open Motors

Shaded Pole Motors

Shaded pole motors are low torque motors which are used to turn fans. They can be used to run evaporator or condensor fans.



1. A shaded pole motor used to run an evaporator fan or condensor fan has one winding and two leads. The electrical connection is shown in this schematic diagram of a shaded pole motor.

2. This shaded pole motor is used as an evaporator fan motor.

3. This shaded pole motor is used as a condensor fan motor.

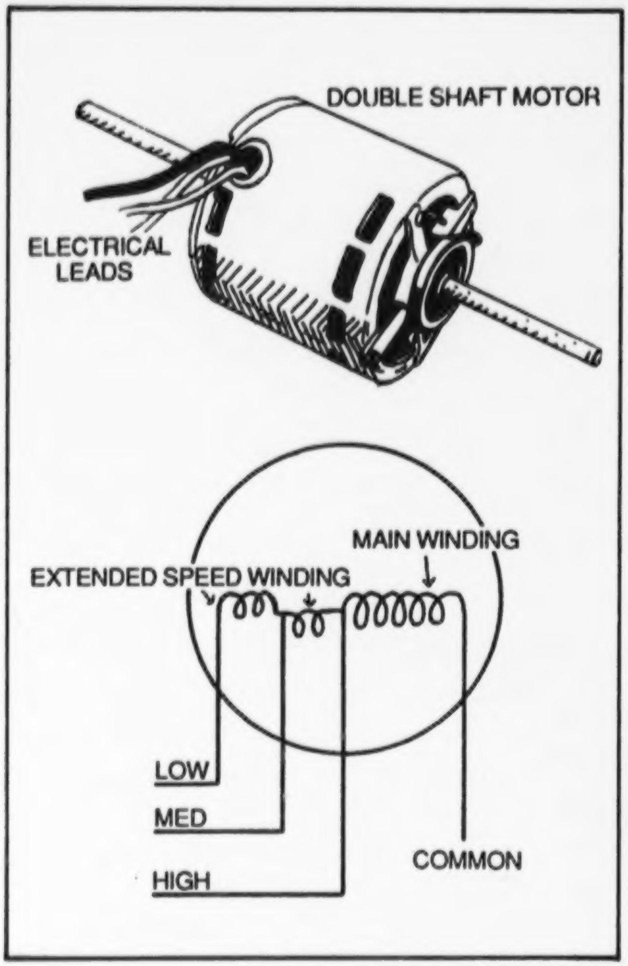
4. An easy way to test a small fan motor is to clip a test cord directly to the motor leads.

CAUTION: BE SURE THE TEST CLIPS ARE INSULATED AND THE MOTOR FRAME IS GROUNDED.

5. The small motors used for fans in domestic refrigerators and freezers cannot be repaired and should be replaced if they will not turn or are noisy.

6. Larger shaded pole motors with double shafts are used in some window air conditioners.

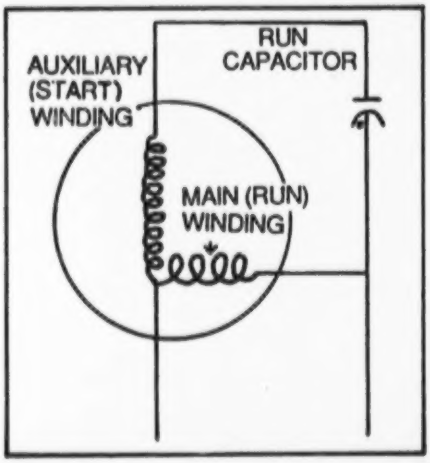
7. The larger shaded pole motors may have more than two leads coming from the motor. The extra leads are for changing the motor speed. Here is the schematic diagram for a shaded pole motor with extended speed windings.


DOUBLE SHAFT MOTOR
ELECTRICAL LEADS
MAIN WINDING
EXTENDED SPEED WINDING
LOW
MED
HIGH
COMMON

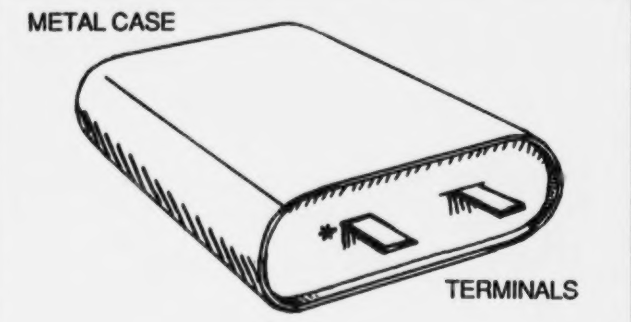
PERMANENT SPLIT CAPACITOR MOTORS

Permanent split capacitor motors are often called PSC motors. They are used to run fans and compressors in many window air conditioners. PSC motors are also used as the compressor motors for some central air conditioners and heat pumps.

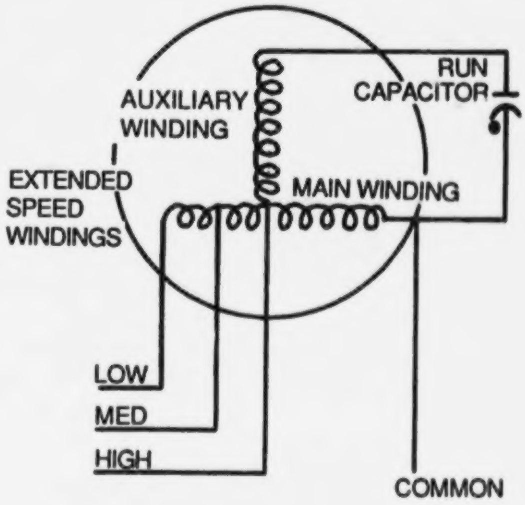
1. A PSC motor has two windings, a main winding (sometimes called a run winding), and an auxiliary winding (sometimes called a start winding).


AUXILIARY (START) WINDING
RUN CAPACITOR
MAIN (RUN) WINDING

2. A double shaft PSC motor looks very much like a double shaft shaded pole motor. A PSC motor is always connected to a run capacitor.


METAL CASE
*
TERMINALS

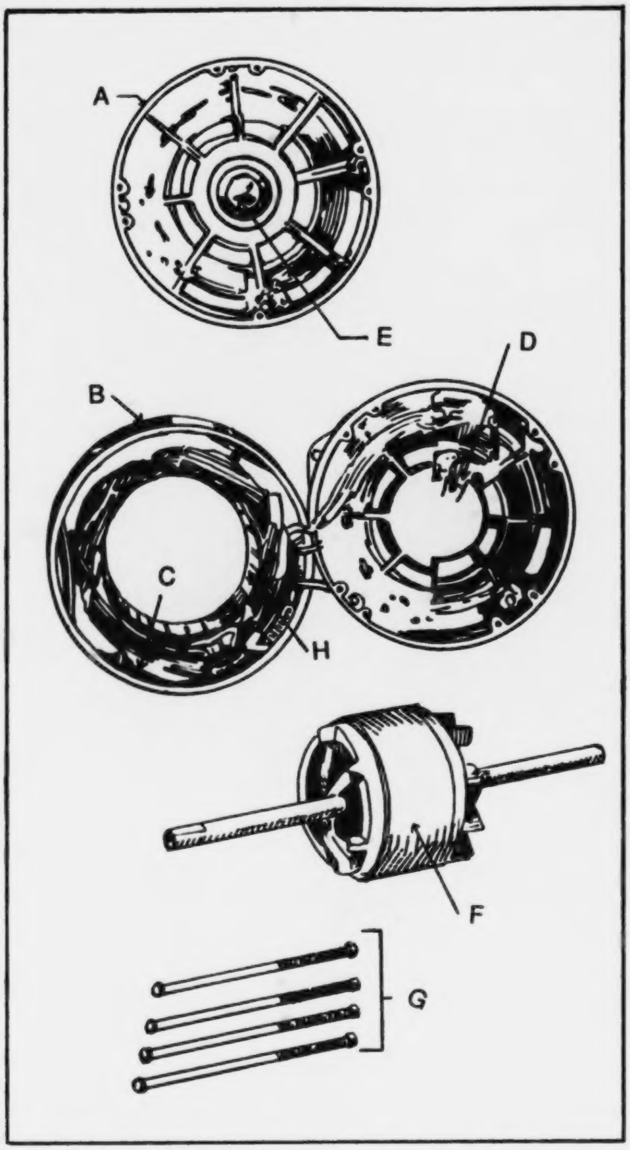
3. PSC motors used to turn fans and blowers may also have extra leads for changing speed. This is the schematic diagram for a PSC motor with extended speed windings.


RUN CAPACITOR
AUXILIARY WINDING
EXTENDED SPEED WINDINGS
MAIN WINDING
LOW
MED
HIGH
COMMON

4. Both the double shaft shaded pole fan motor and the double shaft PSC motor have parts that look like these shown in the picture. These parts are:

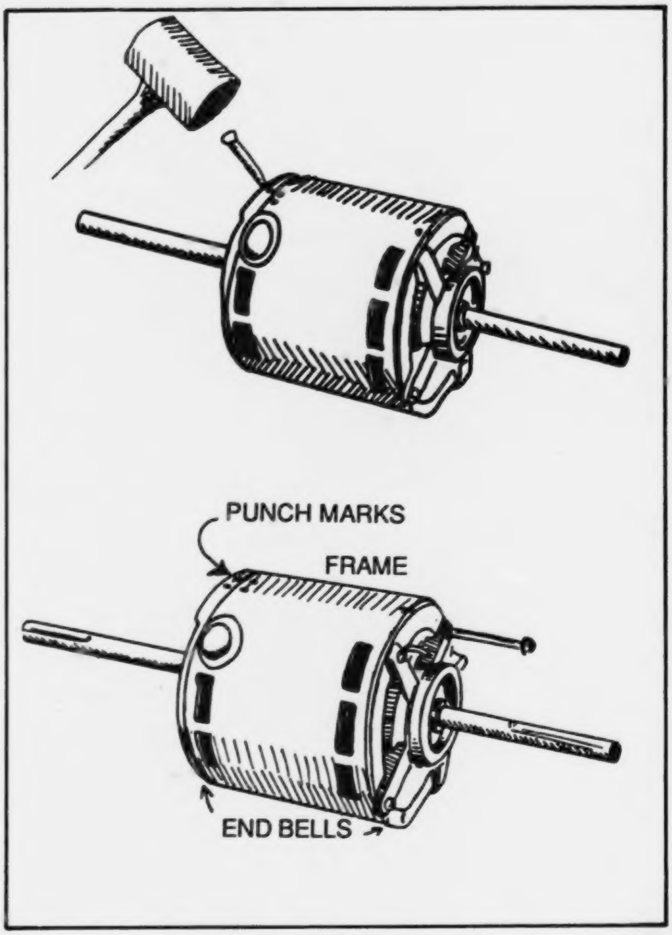
   a. End bells
   b. Frame
   c. Stator winding
   d. Overload (not on all motors)
   e. Sleeve bearings
   f. Double shaft rotor
   g. Assembly bolts
   h. Stator

NOTE: This type of motor does not have a starting switch.



C. Steps of Procedure for Disassembling, Inspecting, Cleaning, and Reassembling a Fan Motor

1. To keep the end bells in their proper place, mark end bells and frame with center punch.



2. Place one mark on one end bell and two marks on the other end bell. Place matching marks on the frame next to marks on the end bell.
3. Using a fine file and emery cloth, remove any burrs from the shaft.
4. Now clean the outside of the motor using a damp rag and detergent or cleaning fluid.

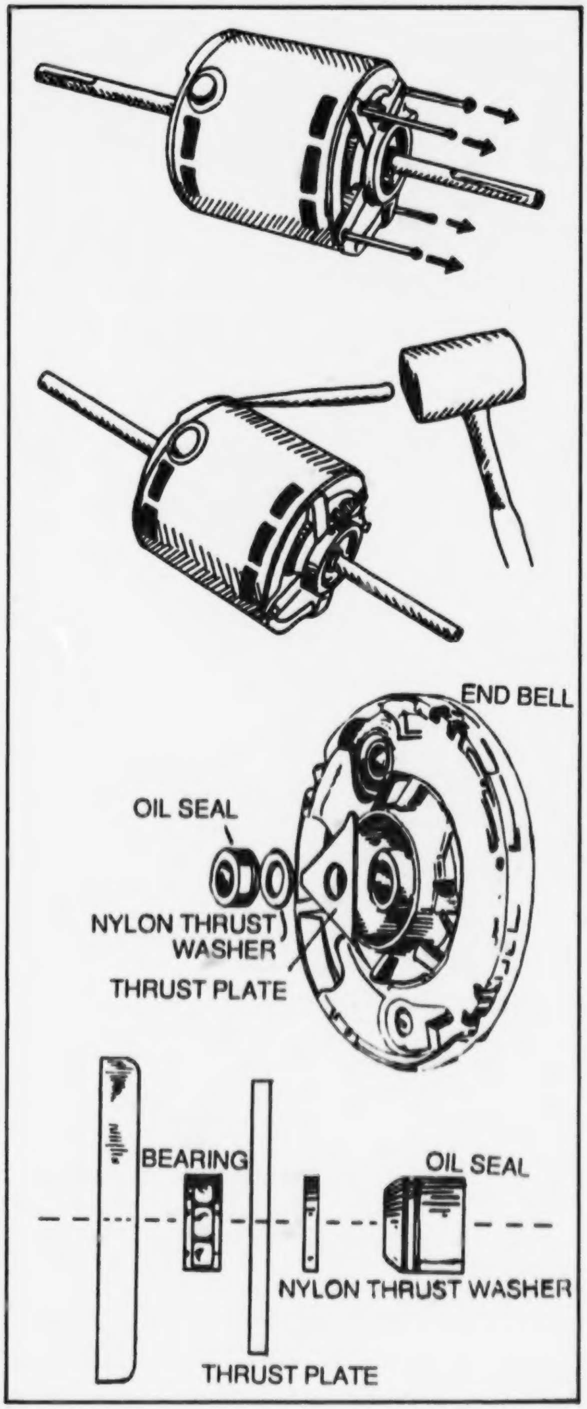
5. Remove assembly bolts.

6. Use a soft-face hammer and drift punch to tap the end bells loose.

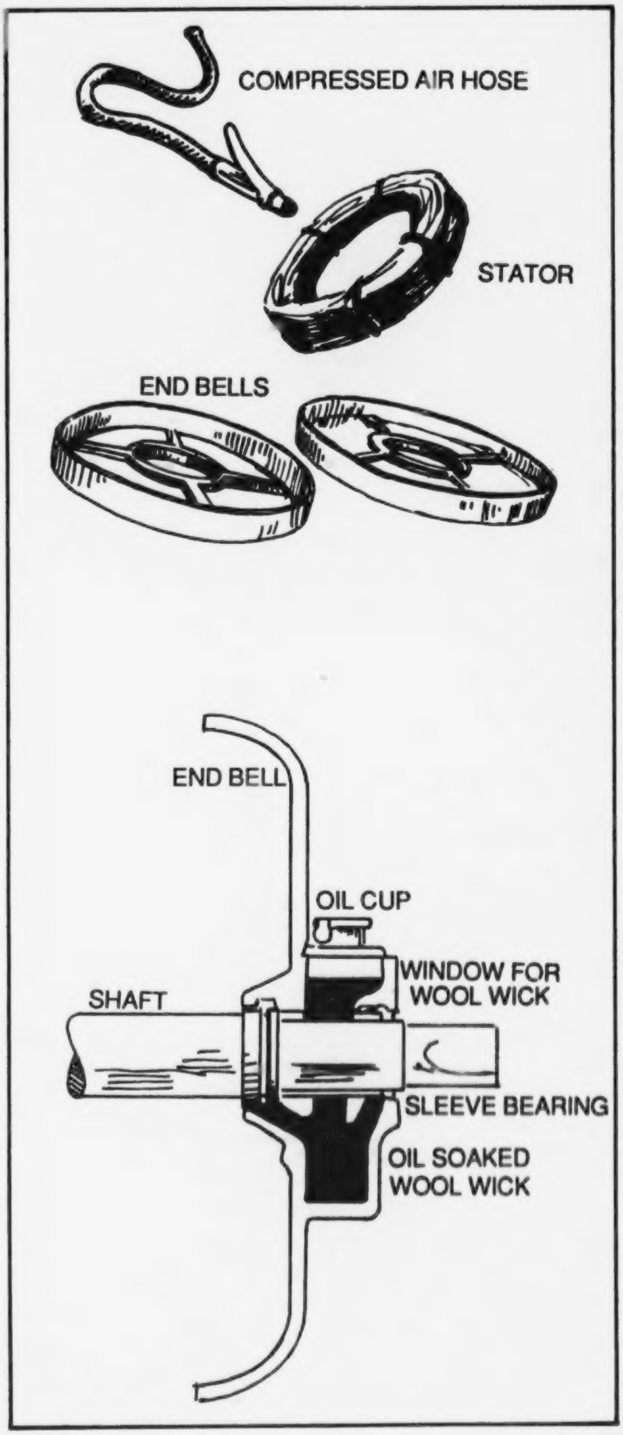
7. Remove the end bells and take note of any washers, shims, seals, bushings, or thrust plates.

   NOTE: These parts may not be found on all motors.

8. Make a simple drawing of how the shims, seals, washers, etc., are placed on the shaft. This will help you when you put the motor back together (reassemble it).


END BELL
OIL SEAL
NYLON THRUST WASHER
THRUST PLATE
BEARING
OIL SEAL
NYLON THRUST WASHER
THRUST PLATE

9. Remove the rotor.


COMPRESSED AIR HOSE
STATOR
END BELLS
END BELL
OIL CUP
WINDOW FOR WOOL WICK
SHAFT
SLEEVE BEARING
OIL SOAKED WOOL WICK

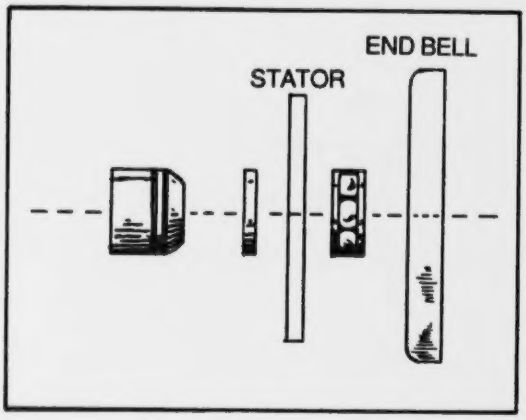
10. Clean the motor with a stiff bristle paint brush or blow out with compressed air (clean stator and both end bells).

CAUTION: DO NOT BLOW COMPRESSED AIR INTO THE BEARING AREA.

11. Clean bearing cavity with a soft clean cloth. Make sure the wick is in place and oiled.

    This drawing shows the location of the wick in a typical sleeve-type bearing.

12. Inspect the motor for cracked or chipped insulation and for damaged wires.

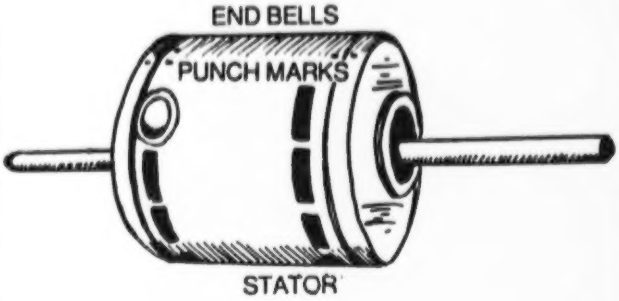


13. Replace one end bell.

14. Inspect the rotor, making sure shims, seals, washers, etc., are in place.

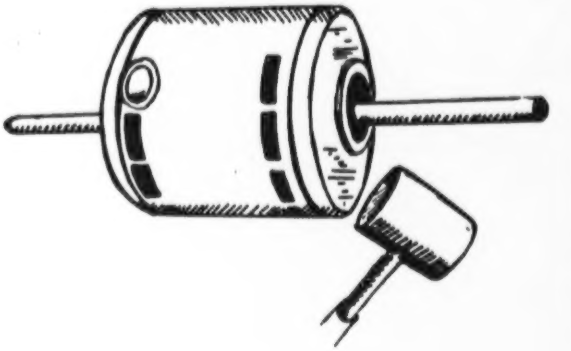
15. Place a drop of oil on the bearing part of the shaft.

16. Visually inspect rotor and stator alignment.

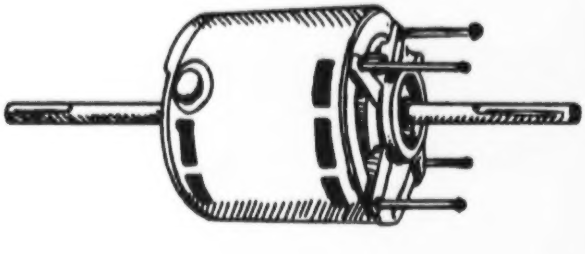


17. Replace the other end bell and check the position of center punch marks.

18. Use a soft face hammer to tap end bells into place.



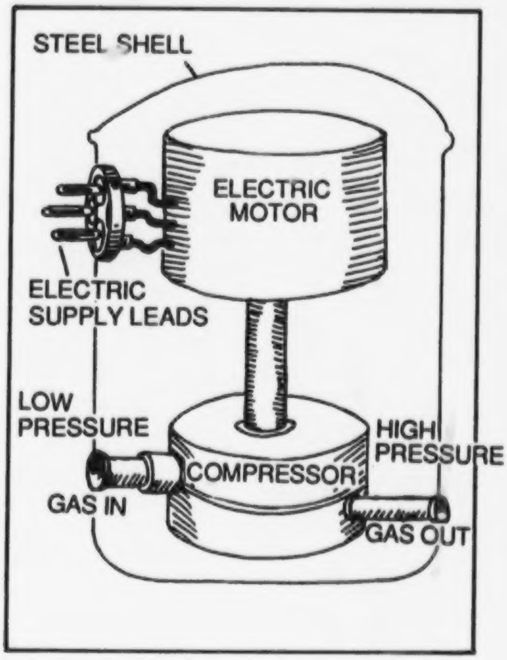
19. Insert assembly bolts.



20. Turn shaft by hand.

D. Hermetic Compressor Motors

A hermetic motor is one that is connected to the compressor that it turns and both motor and compressor are seal welded into a steel container. Electrical connections to the motor are made by three pin terminals that pass through a glass insulator.


STEEL SHELL
ELECTRIC MOTOR
ELECTRIC SUPPLY LEADS
LOW PRESSURE
GAS IN
COMPRESSOR
HIGH PRESSURE
GAS OUT

1. This drawing shows the basic construction of a hermetic motor compressor.

   NOTE: In this unit, we will discuss only motors. Compressors are covered in another unit.

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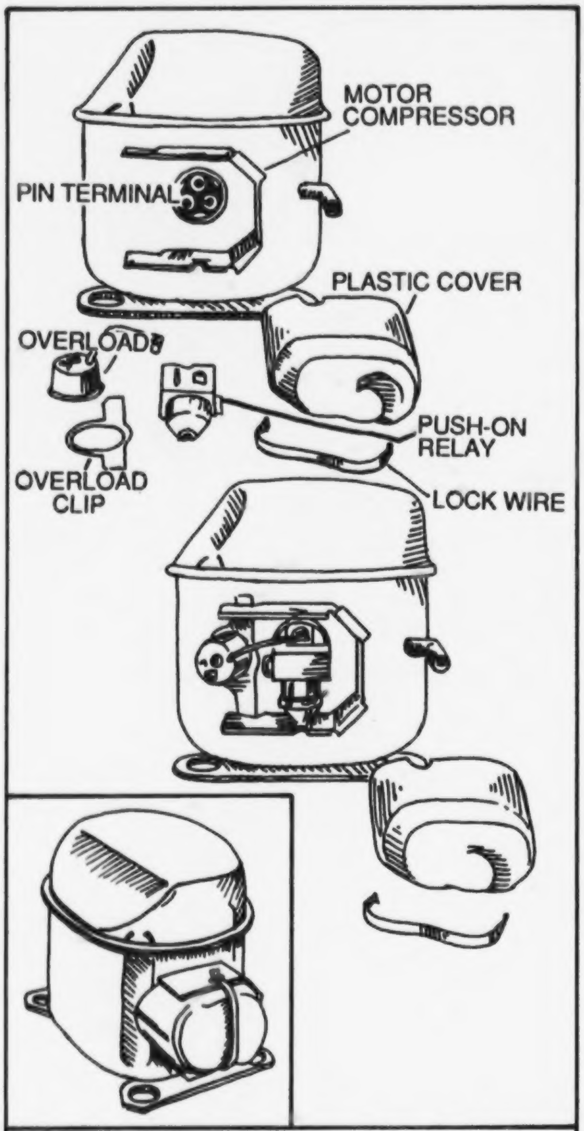
2. These three drawings show the electrical components and how they are connected to the compressor motor.

   NOTE: Not all motors have all the parts shown.

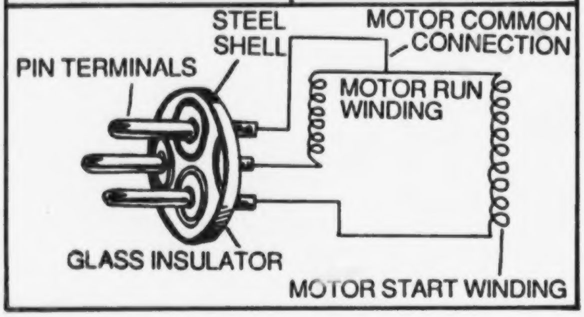
   - Here, overload and relay are shown in assembled position.

   - Here the completely assembled compressor motor with cover and lock wire in place is shown.


MOTOR COMPRESSOR
PIN TERMINAL
PLASTIC COVER
OVERLOAD
PUSH-ON RELAY
OVERLOAD CLIP
LOCK WIRE

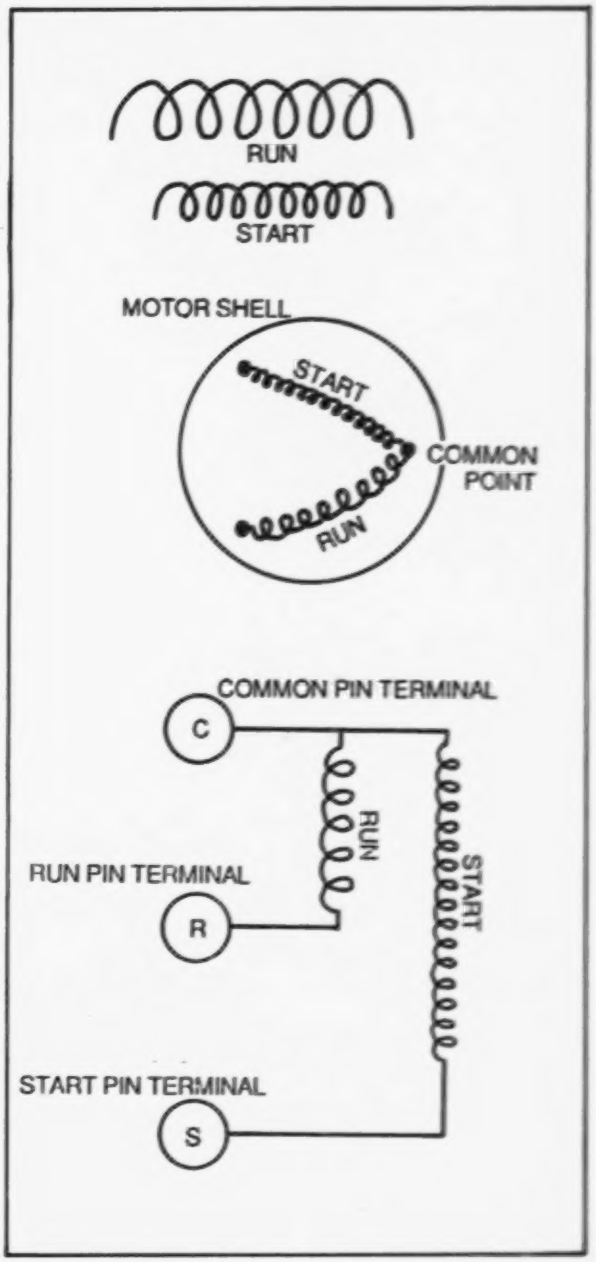
3. This drawing shows the electrical connections to the motor windings and the pin terminals that all hermetic motors have.

   The type of motor can be identified by the kinds of start assist components it is connected to and how it is connected to those components.


STEEL SHELL
MOTOR COMMON CONNECTION
PIN TERMINALS
MOTOR RUN WINDING
GLASS INSULATOR
MOTOR START WINDING

Common Characteristics of All Hermetic Motors Used in Domestic Refrigeration

Before looking at the different types of motors used as hermetic motors, you should be able to recognize the things that are the same on all hermetic motors used in domestic refrigeration.


RUN
START
MOTOR SHELL
START
COMMON POINT
RUN
COMMON PIN TERMINAL
C
RUN
START
RUN PIN TERMINAL
R
START PIN TERMINAL
S

1. All hermetic motors have two windings.

    - The **run winding** has few turns and **low** resistance.

    - The **start winding** has many turns and **high** resistance.

    NOTE: The windings of a hermetic motor are just like the windings of an open type motor.

2. All hermetic motors have the two windings connected to a common point inside the motor.

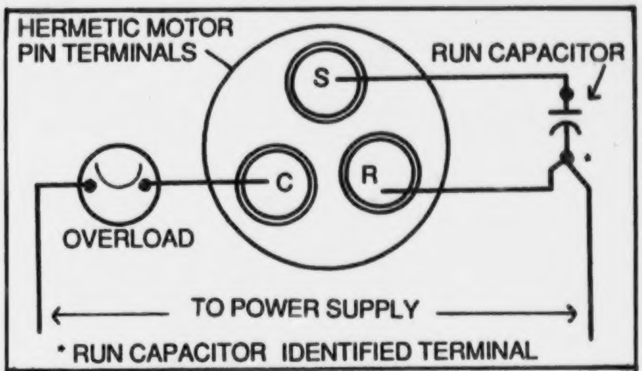
3. All hermetic motors have the end of the run winding (R), the end of the start winding (S), and the common connection (C), connected to pin terminals. Electrical power leads and components are then connected to the motor through the pin terminals.

E. Types of Hermetic Compressor Motors

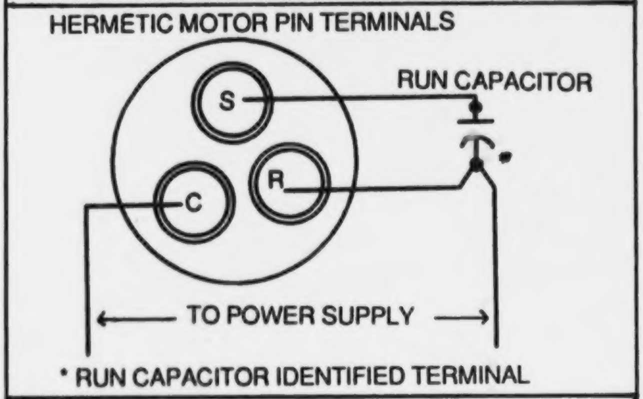
1. Permanent Split Capacitor (PSC) Motor Used As a Hermetic Motor

The PSC type of hermetic motor is commonly used in air conditioners and heat pumps. The PSC motor is connected to a run capacitor and may have an internal or external overload.

- This PSC motor hookup has an external overload.

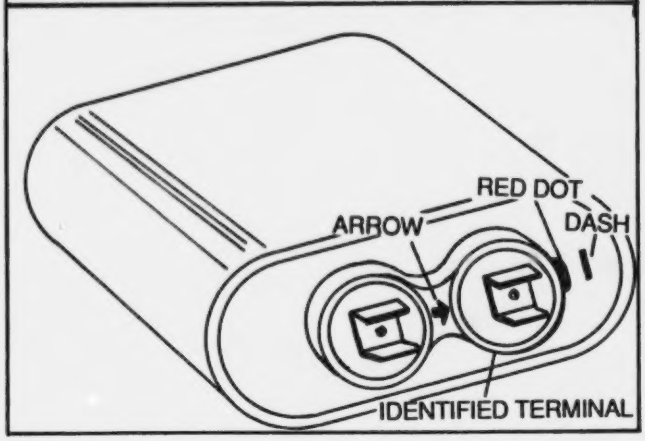

HERMETIC MOTOR PIN TERMINALS
RUN CAPACITOR
S
C
R
OVERLOAD
TO POWER SUPPLY
* RUN CAPACITOR IDENTIFIED TERMINAL

- This PSC motor hookup has an internal overload.

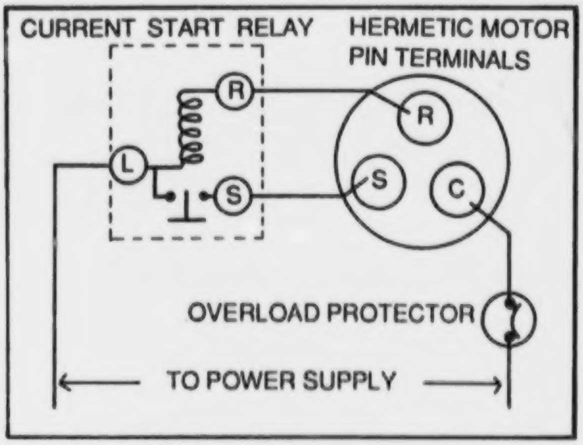

HERMETIC MOTOR PIN TERMINALS
RUN CAPACITOR
S
C
R
TO POWER SUPPLY
* RUN CAPACITOR IDENTIFIED TERMINAL

The run capacitor may have an **identified terminal**. The identified terminal may be marked with a **dash, a dot, a dab of red paint**, or **an arrow**.

If the run capacitor has an identified terminal, **THE IDENTIFIED TERMINAL MUST BE CONNECTED TO** the lead going to **THE RUN MOTOR TERMINAL** and not the start motor terminal.

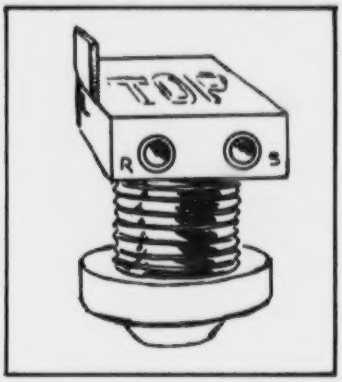

RED DOT
ARROW
DASH
IDENTIFIED TERMINAL

2. Split Phase Motor Used As a Hermetic Motor


CURRENT START RELAY
HERMETIC MOTOR PIN TERMINALS
R
L
S
R
S
C
OVERLOAD PROTECTOR
TO POWER SUPPLY

The split phase motor is commonly used in domestic refrigerators and freezers. This type of motor will be connected to a current type of start relay and to an external overload.

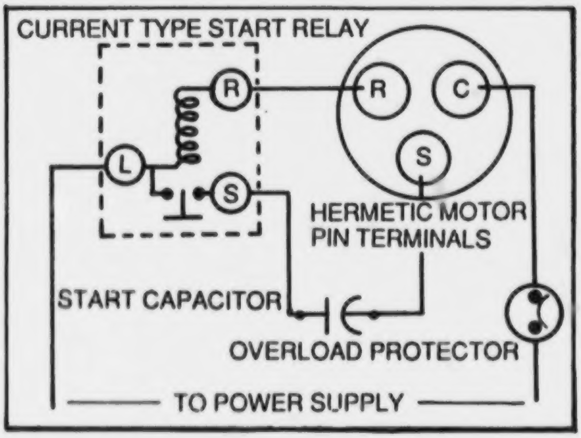
A common type of start relay pushes on over the "R" and "S" pin terminals. The top of the relay will be marked.



CAUTION: DO NOT PUT THIS TYPE OF RELAY ON UPSIDE DOWN OR THE MOTOR WILL BE DAMAGED.

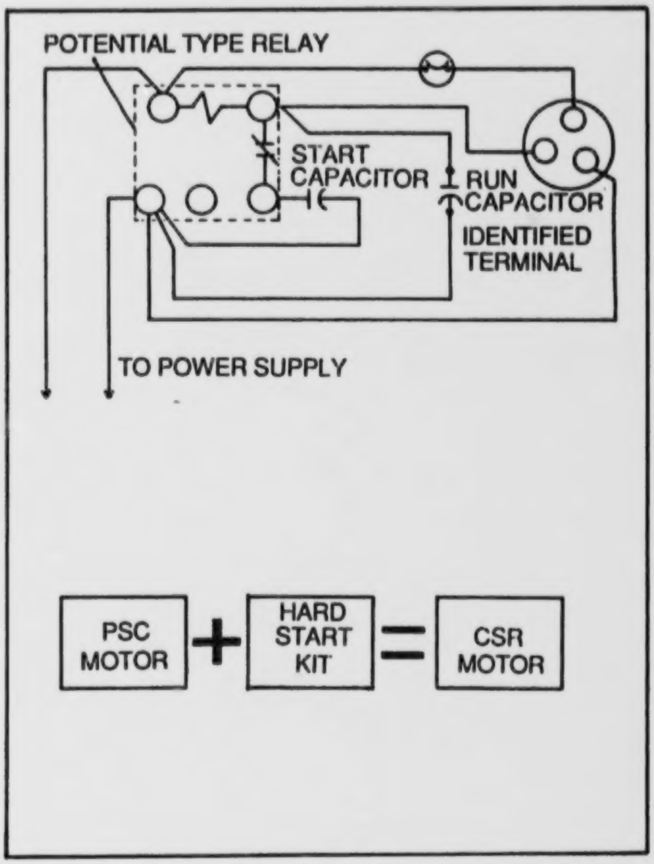
3. Capacitor Start Induction Run (CSIR) Motor Used As a Hermetic Motor

The CSIR motor is commonly used in domestic refrigerators and freezers. This type of motor is connected to a start capacitor, as well as to a relay and overload.


CURRENT TYPE START RELAY
R
L
S
R
C
S
HERMETIC MOTOR PIN TERMINALS
START CAPACITOR
OVERLOAD PROTECTOR
TO POWER SUPPLY

4. Capacitor Start Capacitor Run (CSR or CSCR) Motor Used As a Hermetic Motor

The CSIR motor is commonly used in central air conditioners and heat pumps. This type of motor is connected to a potential type start relay, an internal or external overload, a run capacitor, and a start capacitor.


POTENTIAL TYPE RELAY
START CAPACITOR
RUN CAPACITOR
IDENTIFIED TERMINAL
TO POWER SUPPLY
PSC MOTOR
+
HARD START KIT
=
CSR MOTOR

NOTE: Hard start kits are available to give a PSC motor extra starting torque. A hard start kit makes a permanent split capacitor motor act like a CSIR motor. Instructions for installing a hard start kit come with the kit.

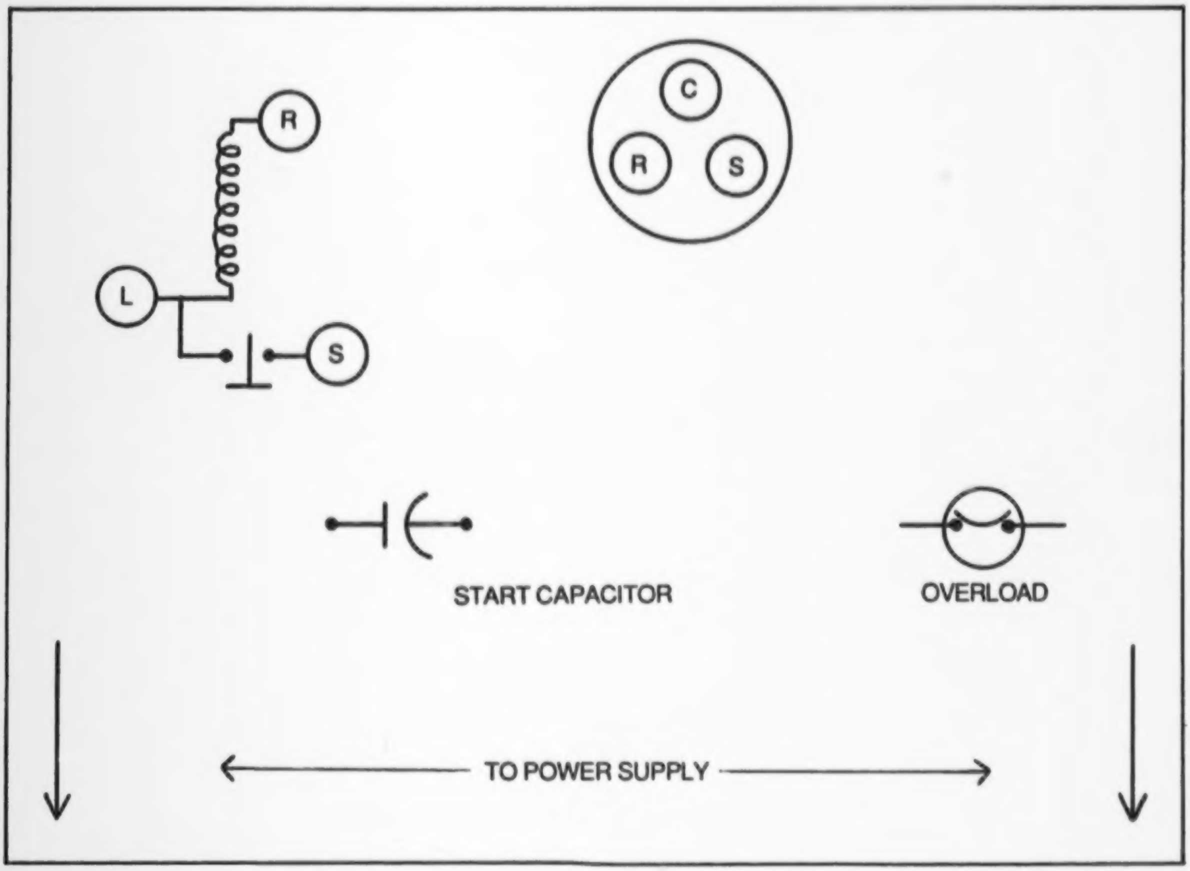
NOTE: Always discharge start and run capacitors with a 20,000 ohm, 2 watt resistor.

DO SKILL SHEET 1.

ELECTRIC MOTORS

SKILL SHEET 1 - ELECTRICAL CONNECTIONS

Directions: Draw in the Electrical Connections.


R
C
R
S
L
S
START CAPACITOR
OVERLOAD
TO POWER SUPPLY

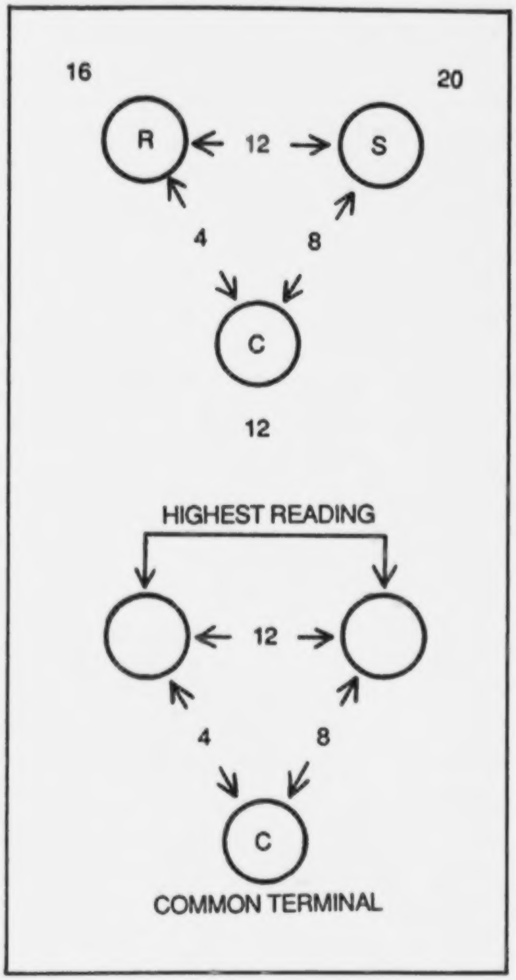
F. Identifying Hermetic Motor Terminals

The common "C," start "S," and run "R" pin terminals are **NOT** always in the same position and most of the time they are not marked. This section shows how to identify the "C," "S," and "R" terminals of any hermetic motor.

1. Use an ohmmeter to measure the resistance between all three terminals.

2. Find the two terminals that give the highest reading when the meter leads are attached to them. The remaining terminal (the one that a meter lead is not connected to) is common (C).

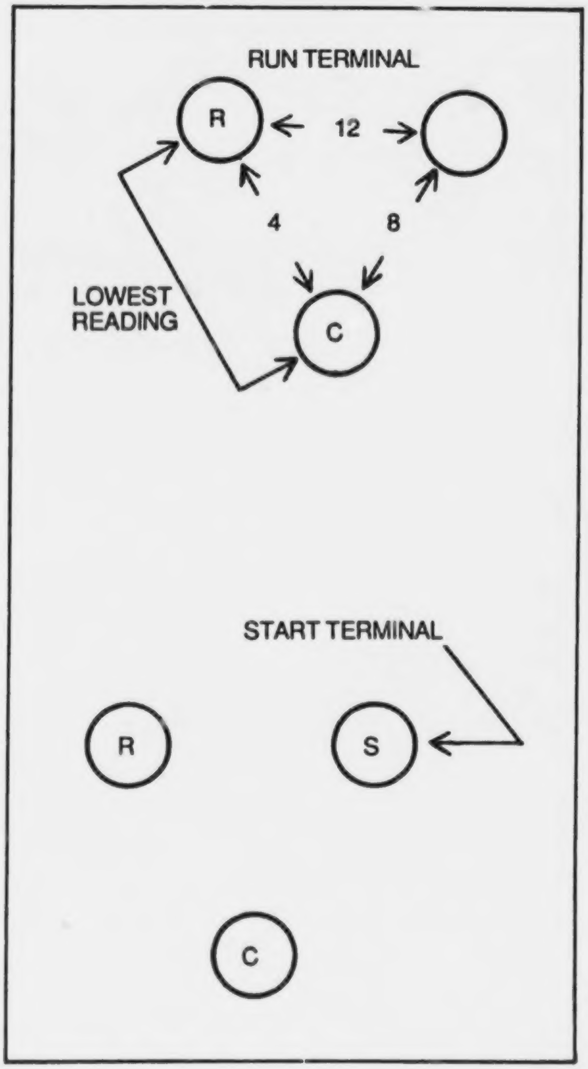
   Now that you have found common, mark it.



3. Move your meter leads to find the two terminals that give the lowest reading. When your meter leads are on the terminals that give the lowest reading, one terminal is common and the other terminal is run.

   Since one of these terminals is already marked common, the other must be run (R).

   Now that you have found run, mark it.



4. The one remaining unmarked terminal must be the start (S) of a hermetic motor.

   Mark this terminal start.

5. Now you have identified the common (C), run (R), and start (S) terminals of a hermetic motor.

DO SKILL SHEET 2.

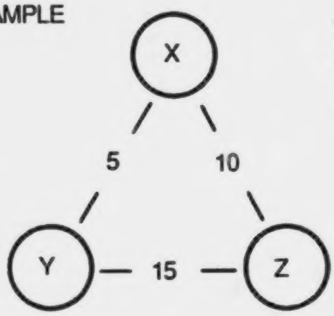
ELECTRIC MOTORS

SKILL SHEET 2

IDENTIFYING HERMETIC MOTOR TERMINALS

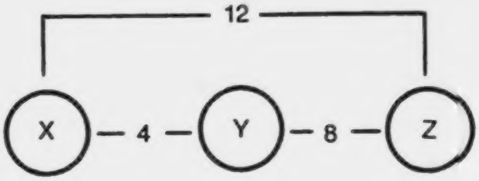
Directions: Identify the hermetic motor terminals.

EXAMPLE

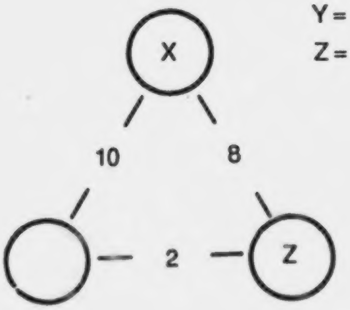


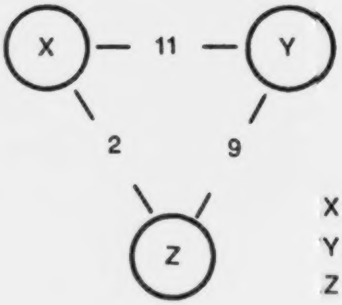
X = C
Y = R
Z = S

X =
Y =
Z =

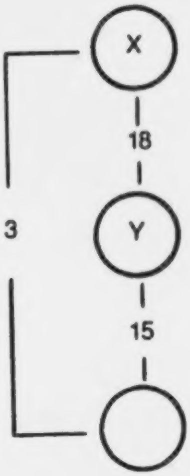


X =
Y =
Z =





X =
Y =
Z =



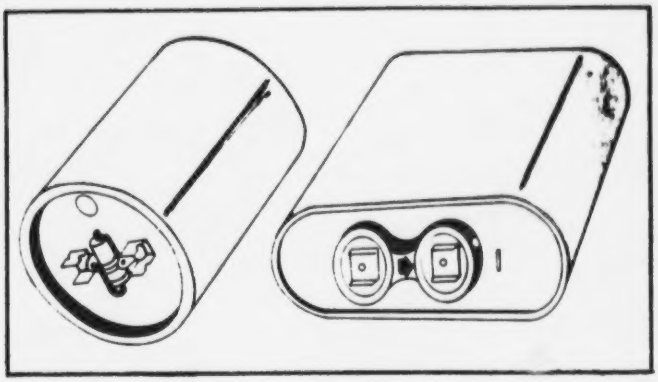
X =
Y =
Z =

G. Testing Motor Capacitors

1. TURN OFF POWER.

2. Short the capacitor terminals with a 20,000 ohm, 2 watt resistor. If shorted with a screw driver, it could arc the contacts of the relay. Some start capacitors have a resistor soldered between the terminals. It would not be necessary to discharge.

   SHORTING A FUSED RUN CAPACITOR WILL RUIN IT.



3. Test by any of the three methods listed below.

Method #1

Substitute the suspected capacitor with one that you know is good and has the same type voltage and microfarad ratings.

If the motor runs, the old capacitor was bad.

Method #2

Use a capacitor tester.
Follow the operating instructions that come with the tester.

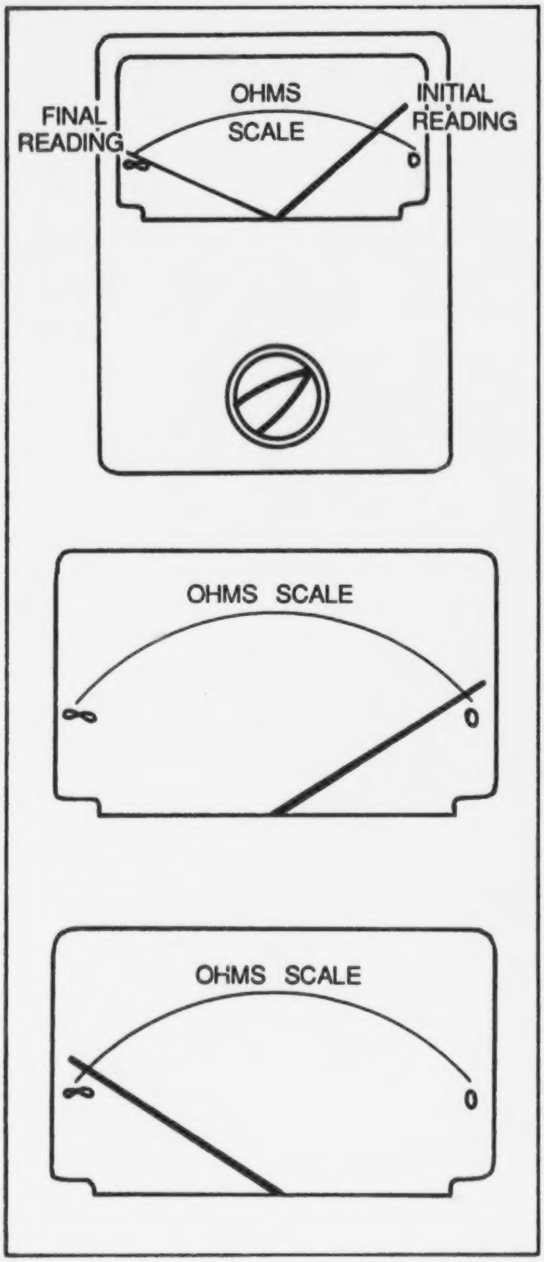
Method #3

Use an ohmmeter with the range selected to rx100 or rx1k and check for continuity between capacitor terminals.

- A good capacitor should make the pointer swing far to the right, then slowly swing back to the left.

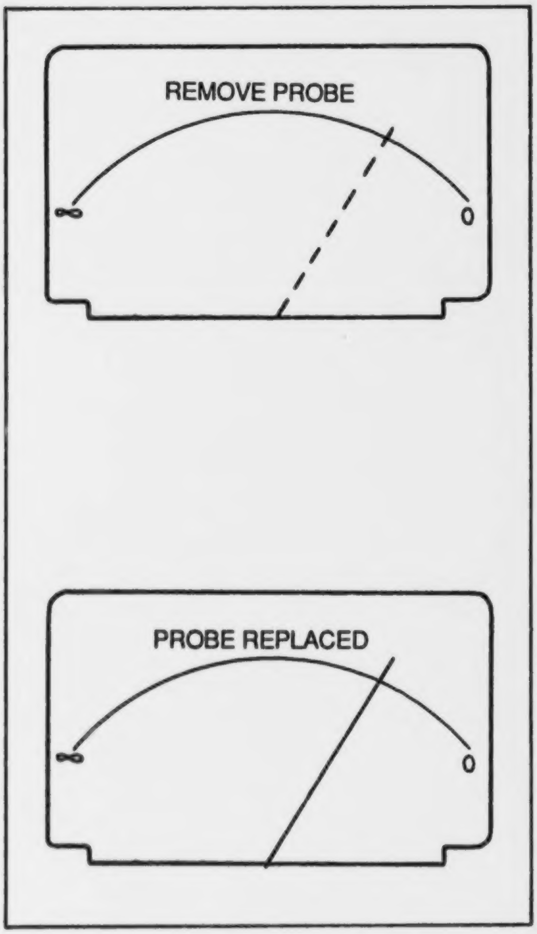
- A pointer that goes to the right and stays indicates a shorted capacitor.

- A pointer that stays to the left indicates an open capacitor.


FINAL READING
OHMS SCALE
INITIAL READING
∞
0
OHMS SCALE
∞
0
OHMS SCALE
∞
0

When Testing A Capacitor Using Method 3.

You can check to see if the capacitor leaks in the following manner.



1. Touch probes to the capacitor. The needle will deflect to the far right toward "0."

2. As the needle descends back toward∞, remove one probe when needle has moved about one-third the distance of the scale.

3. Wait approximately 10 seconds.

4. Then place the probe tip back on the terminal you removed it from. The needle will return to approximately the same position the needle was in when you removed it.

5. This will show the capacitor will hold a charge.

6. If the needle returns to the far right, as in step 1, the capacitor leaks and must be replaced.

NOTE: If you replacing a faulty capacitor, the relay should also be replaced. There is a good possibility it has pitted contacts or poles.

H. Testing Hermetic Motors

1. Check Voltage.

- Check power to be sure full voltage is available.

- Make a voltage check when motor is trying to start.

- Full voltage is equal to name plate voltage ± 10%.

2. Check motor windings.

NOTE: When checking motor windings always set meter in the RXI position.

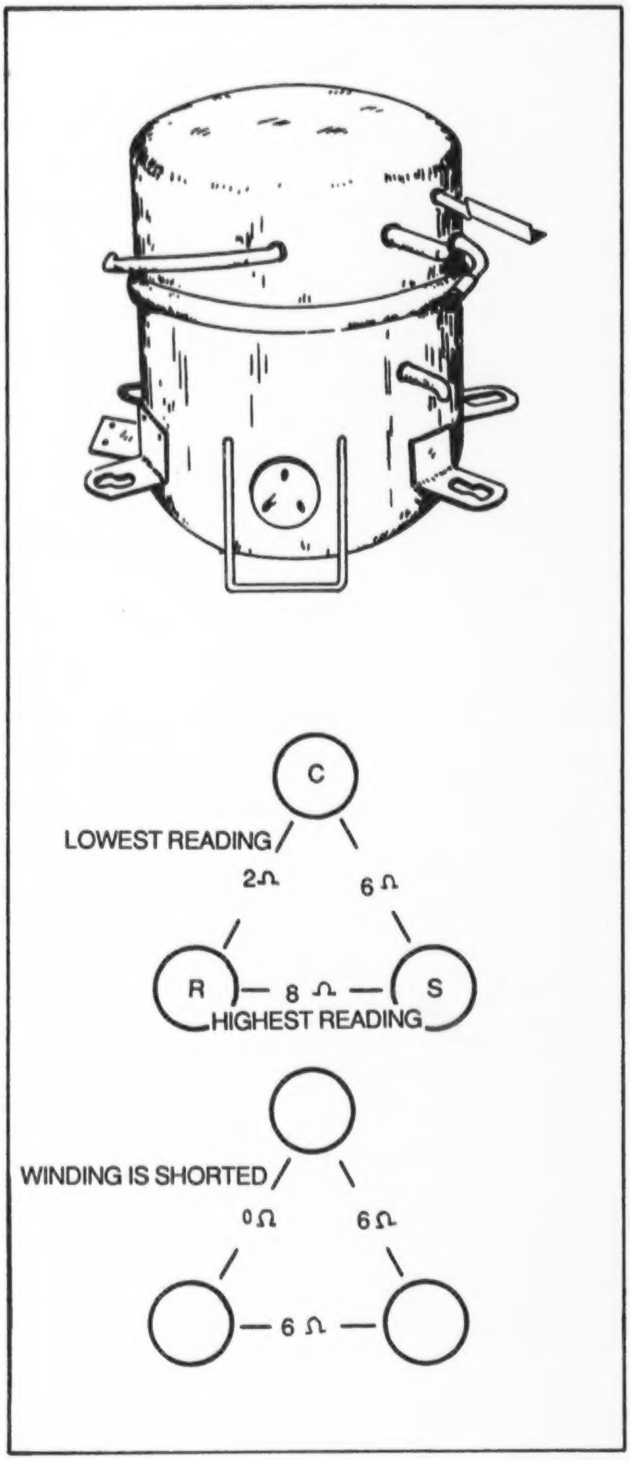
WITH POWER TURNED OFF OR PLUG PULLED.

- Remove all leads and components from motor.

- Take resistance readings to identify C, S, and R terminals.

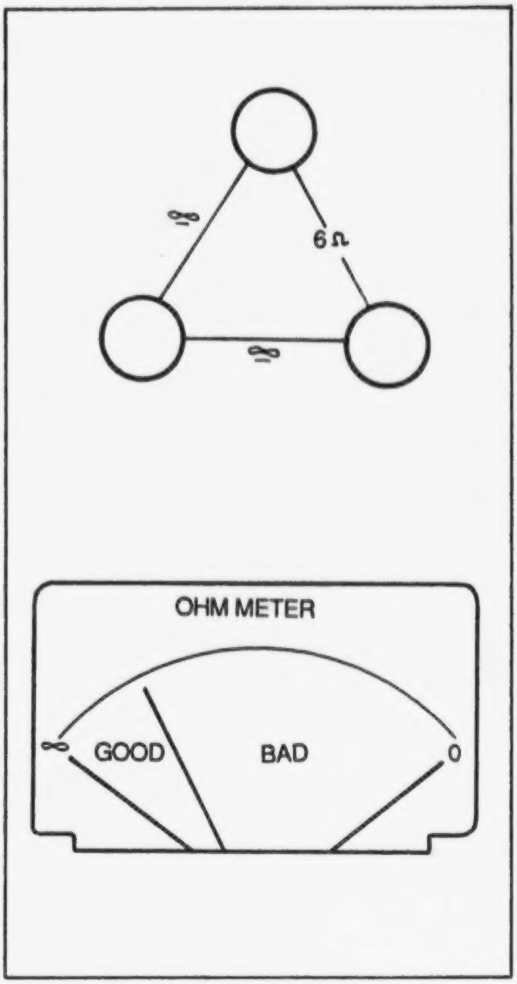
- Some resistance between all terminals is normal and indicates windings are good.

CAUTION: IF MOTOR HAS AN INTERNAL OVERLOAD, IT MUST BE COOL BEFORE IT CAN BE TESTED FOR OPENS.



- Any reading of zero shows a shorted winding. The motor must be replaced.

- Any reading of infinity (∞) shows an open winding. The motor must be replaced.



3. Check the motor for ground.

- Scratch paint from a spot on the motor shell.

- Using a megometer, measure resistance from the bare spot on the motor shell to the motor terminals.

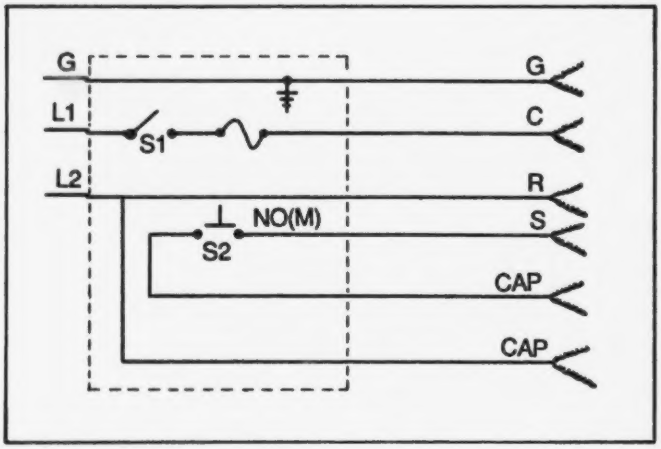
- The reading must be very high to show a good motor. Any resistance below 500,000 shows a bad motor.

Good ground readings = Continue Testing
Bad ground readings = Replace Motor

4. Use motor test cord to start motor.

These are instruction for using the motor test cord.

- Connect test leads as follows:
  - (G) To bare spot on frame
  - (C) To common terminal
  - (R) To run terminal
  - (S) To start terminal



If capacitor is used, connect caps to capacitor (one to each terminal).

If no capacitor is used, connect cap to cap.

- Connect L1 and L2 to power supply.
- Hold down (shut) switch S2.
- Shut switch S1.
- After 2 seconds, take your hand off push button switch S2.

NOTE: If you are testing a PSC motor, omit step 5.

If the motor starts while using the test cord, the motor is good.

If the motor will not start using a test cord:

- Release refrigerant from the system using line tap valve on compressor discharge line.
- After refrigerant is discharged, try to start motor with the test cord again.
- If motor still does not start, it must be replaced.

If the motor does start, there is a restriction in the system that must be corrected.

Important Things to Remember

1. When removing leads from motors and components, make sure all leads are marked so they can be reconnected properly.
2. When replacing components, use exact replacements.
3. Be sure relays are installed right side up.
4. Be sure plastic cover is in place over relay and overload on hermetic compressors.
5. Insure that the identified terminal of the run capacitor is connected to the run winding.

ELECTRIC MOTORS

UNIT REVIEW

Directions: Circle the letter of the best answer.

1. Are hermetic motors used to turn fans and blowers?
   a) Yes
   b) No

2. If a small evaporator fan motor does not work, it should be:
   a) Replaced with a new one
   b) Repaired
   c) Cleaned, oiled, and tested.

3. Do all hermetic motors have run, start, and common terminals connected to the motor windings?
   a) Yes
   b) No

4. Do all hermetic motors use start relays?
   a) Yes
   b) No

5. What type of hermetic motor is commonly used in window air conditioners?
   a) PSC
   b) SCIR
   c) Split phase
   d) Shaded poles

6. What should be done when removing end bells from a motor?
   a) Mark the frame.
   b) Mark the end bells.
   c) All of the above
   d) None of the above

7. You can change bearings on:
   a) Open motors
   b) Hermetic motors
   c) All of the above
   d) None of the above

8. A motor that runs on a test cord, but not when it is installed in a refrigeration system:
   a) Is bad
   b) Should be replaced
   c) All of the above
   d) None of the above

9. May current - type start relays safely be installed upside down?
   a) Yes
   b) No

10. An identified terminal of a run capacitor must be connected to the leads that go to the __________ .

ELECTRIC MOTORS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Disassemble, inspect, clean and reassemble a double-shaft fan motor.			
2. Identify hermetic compressor motors and terminals.			
3. Test motor capacitors.			
4. Test a hermetic motor for faults in the windings.			
5. Operate a hermetic motor on a test cord.			

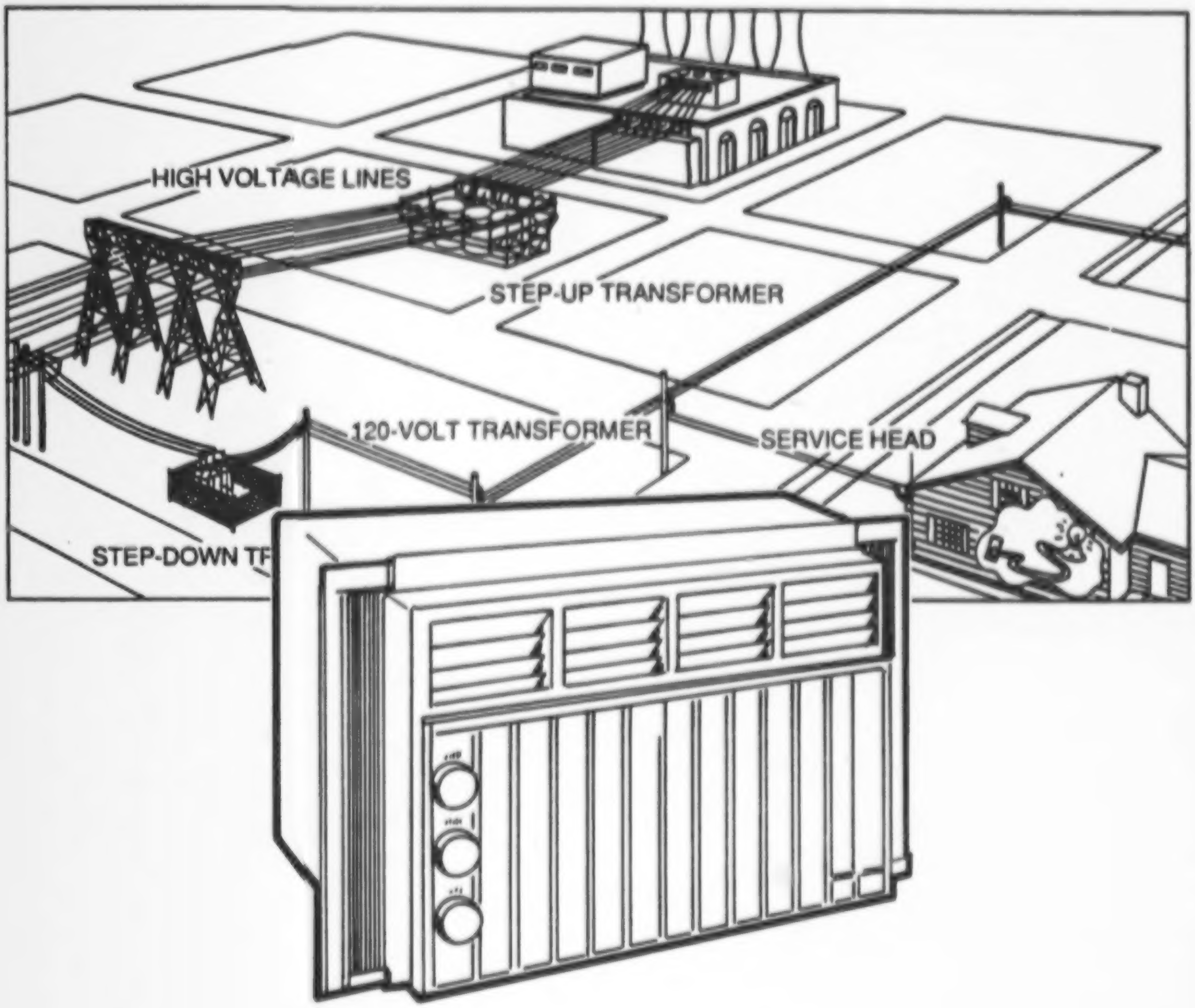
Satisfactory - Should Move On ☐

Repeat This Unit ☐

Student's Signature/Date

Instructor's Signature/Date

90-7040-S
SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 5
Electrical Components

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

Electrical Components

Introduction

Being able to identify and understand the function of electrical components is an important part of troubleshooting. This unit will show you what the components look like and explain the functions of the components. Diagrams will be used to help you understand how the components and systems work.

Unit Objectives

After completion of this unit, you should be able to identify electrical components and wire an electrical system.

Specific Objectives

After completion of this unit, you should be able to specifically:

1. Identify the 14 basic components of air conditioning and refrigeration systems.
2. Explain the function of each component.
3. Identify the symbol for each component.
4. Wire a system using these components.

Check the Statement that Fits You Best

☐ I can do these tasks and want to go through the Performance Checklist.

SEE YOUR INSTRUCTOR

☐ I want to study the information in this unit before I do the Performance Checklist.

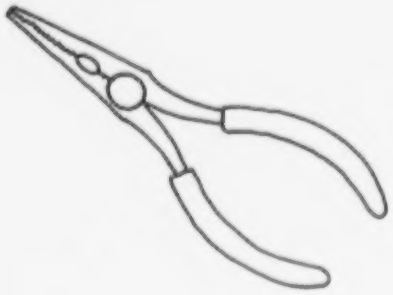
TURN PAGE AND BEGIN

A. Terms and Definitions

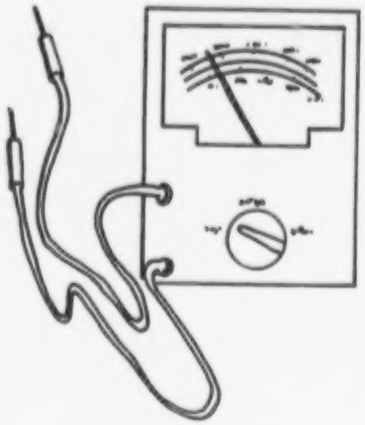
Terms

1. Bimetal - two different metals welded together. Because the two different metals expand at different rates, a bimetal device bends when temperatures change.
2. Capacitor - a device that stores electricity. Capacitors are used to help start motors, increase their efficiency, and improve the power factor.
3. Circuit - the complete path of electrical flow.
4. Components - the main parts or elements of a whole system.
5. Conductor - something which can carry electricity; metals such as silver, copper, and aluminum are conductors.
6. Contact - the connection between two conductors in a circuit or the device that opens and closes this connection.
7. Overload - more power (load) than a system or device is meant to carry.
8. Relay - an electromagnetic switch that opens or closes contacts in a operating circuit.
9. Short circuit - part of a circuit touches another part of circuit and causes electrical current to take the wrong path.
10. Terminal - a connective device or point on an electric circuit or conductor.
11. Thermostat - a device that senses temperature in an environment and then works to control a circuit.

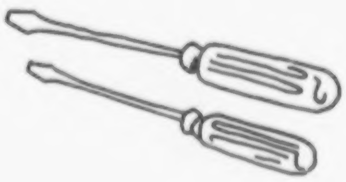
Equipment



NEEDLE NOSE PLIERS



OHMMETER

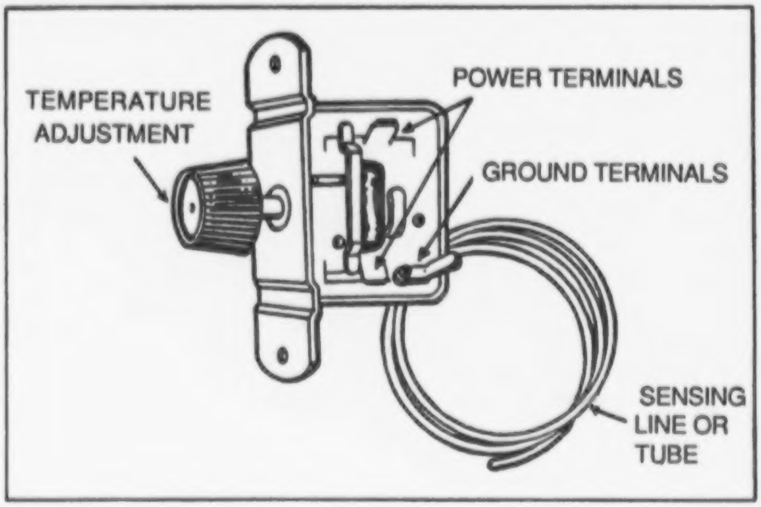


SCREWDRIVER SET

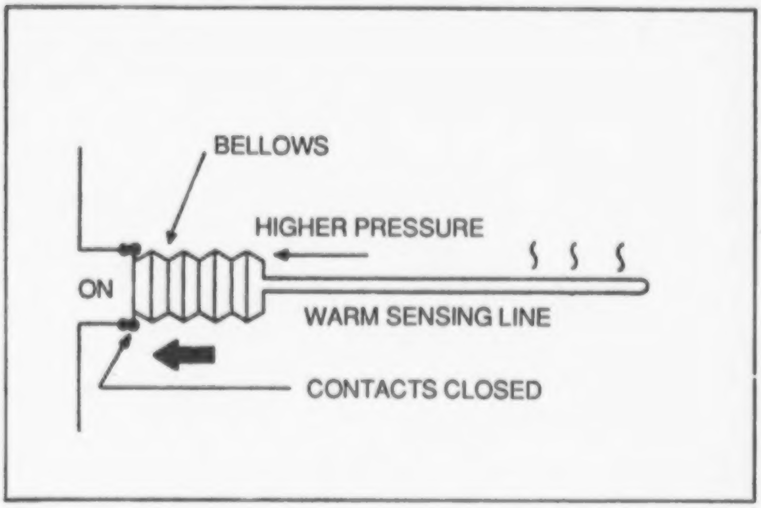
B. Steps of Procedure for Identifying Components and their Uses

1. Thermostat

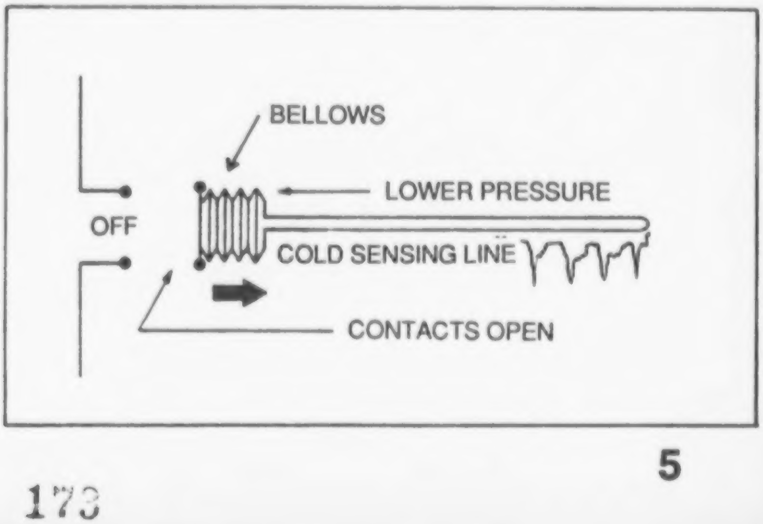
a. The thermostat turns the refrigeration unit on and off as needed.


TEMPERATURE ADJUSTMENT
POWER TERMINALS
GROUND TERMINALS
SENSING LINE OR TUBE

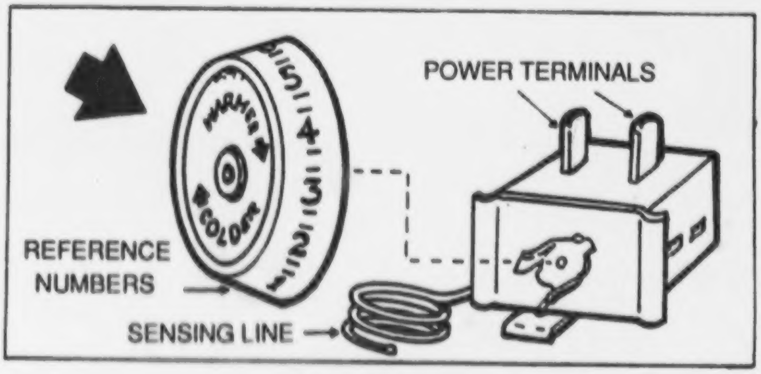
b. When the sensing line of the thermostat gets warm, it builds up pressure inside the bellows. The higher pressure closes the electrical switch contacts.


BELLOWS
HIGHER PRESSURE
ON
WARM SENSING LINE
CONTACTS CLOSED

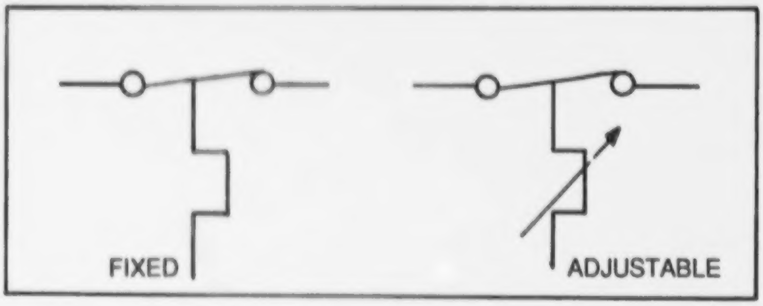
c. When the sensing line gets cold, the pressure becomes lower and the switch contacts open.


BELLOWS
LOWER PRESSURE
OFF
COLD SENSING LINE
CONTACTS OPEN

d. The temperature adjustment dial acts as a cover over the thermostat.

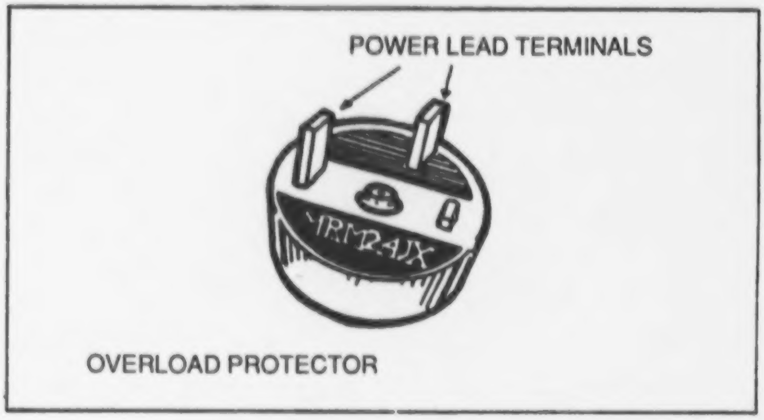

POWER TERMINALS
WARMER
COLDER
5
4
3
2
1
REFERENCE NUMBERS
SENSING LINE

e. On drawings and diagrams, a thermostat is usually shown with these symbols.


FIXED
ADJUSTABLE

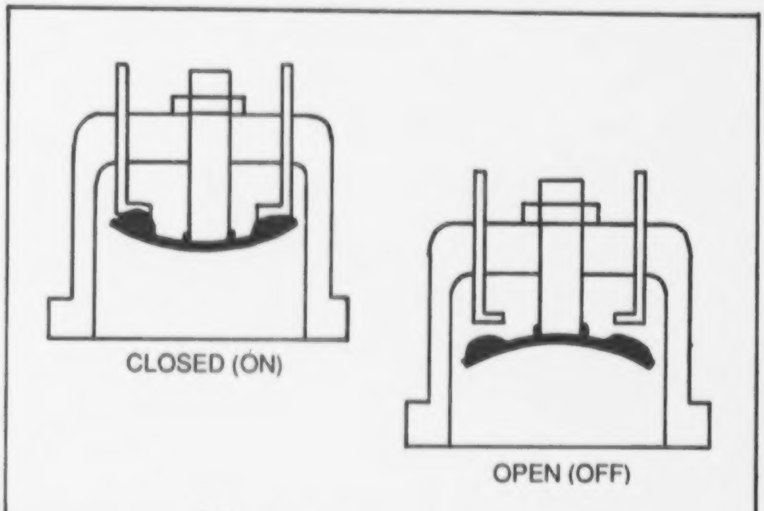
2. **Overload Protector**

a. An overload protector is a type of thermostat that protects the compressor motor from getting too hot if the motor becomes overloaded.
NOTE: When a motor becomes overloaded, it draws too much current. The extra current will cause the motor to become hot. If the motor gets too hot, it will be damaged or destroyed.

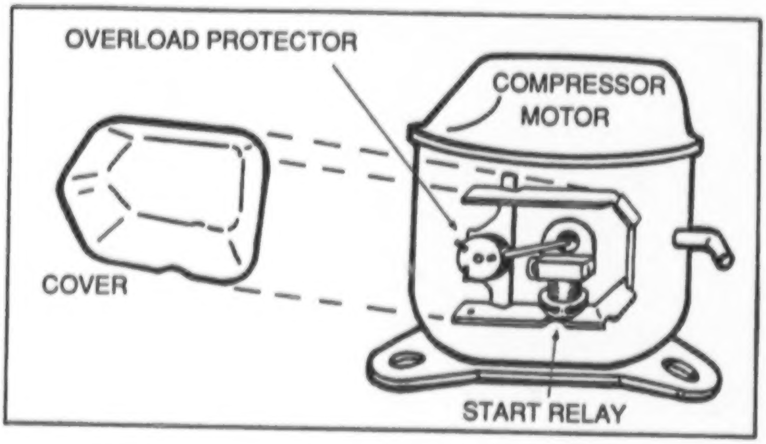

POWER LEAD TERMINALS
TRM24JX
OVERLOAD PROTECTOR

b. The overload protector uses a snap action bimetal disc. The bimetal disc is normally closed.

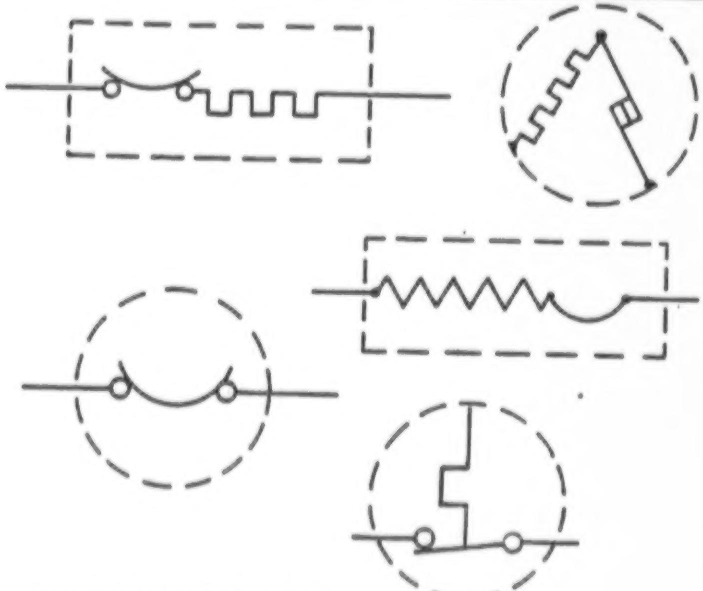
c. If the bimetal disc becomes hot, it will snap open and turn off the power to the motor.


CLOSED (ON)
OPEN (OFF)

d. The overload protector is located under a protective cover on the side of the compressor motor. This allows the overload to open any time the compressor motor gets too hot.


OVERLOAD PROTECTOR
COMPRESSOR MOTOR
COVER
START RELAY

e. A variety of names and symbols are used to show overload protectors on diagrams. Names such as snap disc, guardette, protector, motor protector, or klixon are often used.

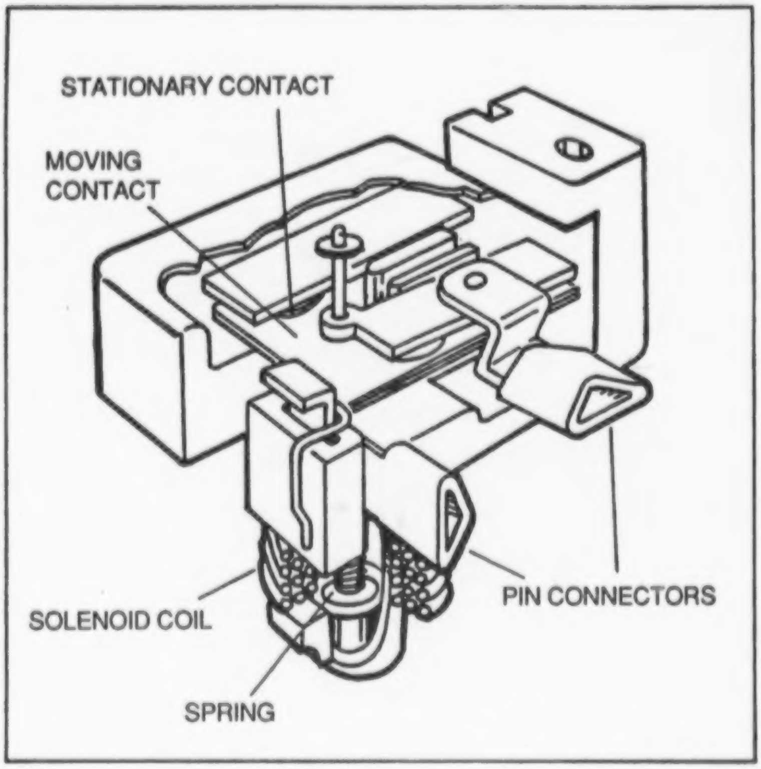


COMMON SYMBOLS FOR OVERLOAD PROTECTORS

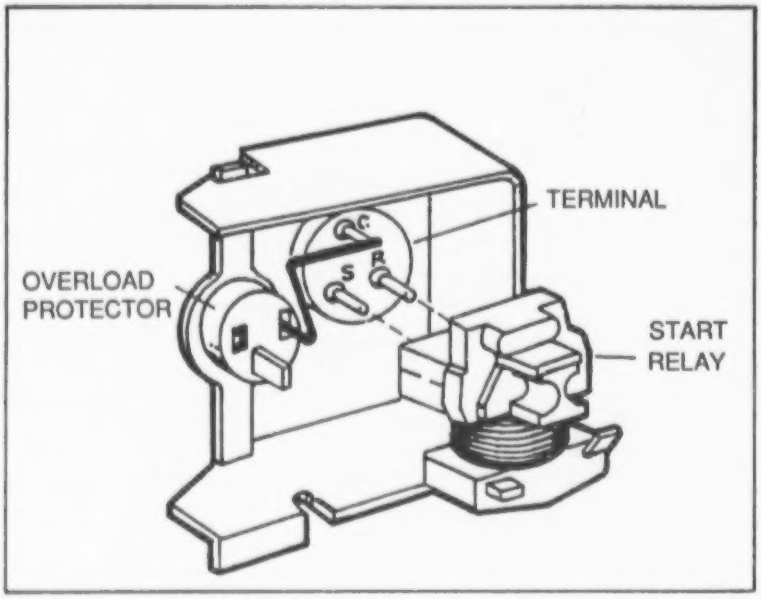
3. Start Relays

a. Some types of motors need start windings and start capacitors to begin turning. After the motor reaches 85% of its full speed, a start relay is used to turn off the start winding and start capacitor.

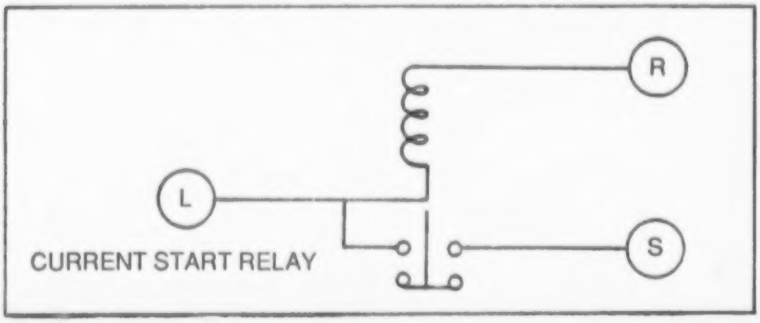
NOTE: A current relay is the most common type of start relay.


STATIONARY CONTACT
MOVING CONTACT
PIN CONNECTORS
SOLENOID COIL
SPRING

b. Start relays are located under the same protective cover as the overload protector.

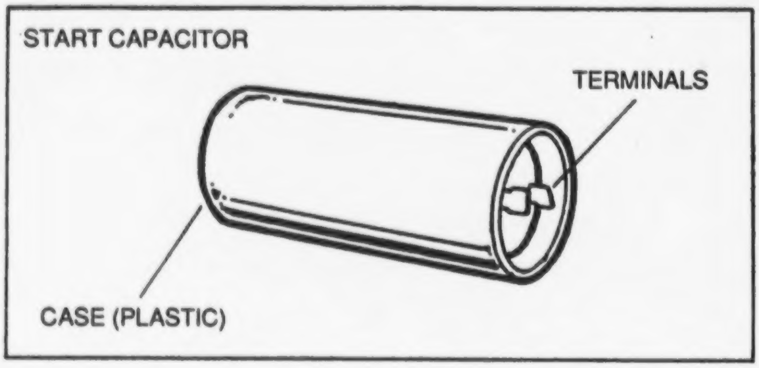

TERMINAL
C
S
R
OVERLOAD PROTECTOR
START RELAY

c. Here is a common symbol for a current start relay.


R
L
S
CURRENT START RELAY

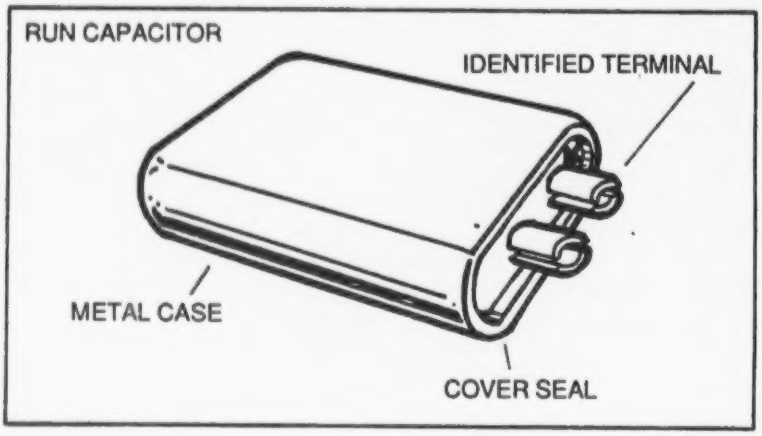
4. Capacitors

a. Start capacitors are used to help some types of motors start turning. Start capacitors can only be energized for a few seconds or they will be destroyed.

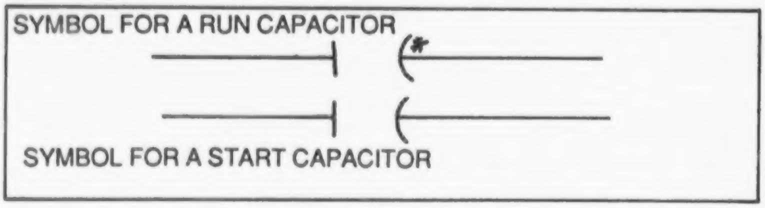

START CAPACITOR
TERMINALS
CASE (PLASTIC)

b. Run capacitors make some types of motors run more efficiently and easily.

NOTE: There is no limit on how long a run capacitor can be energized.


RUN CAPACITOR
IDENTIFIED TERMINAL
METAL CASE
COVER SEAL

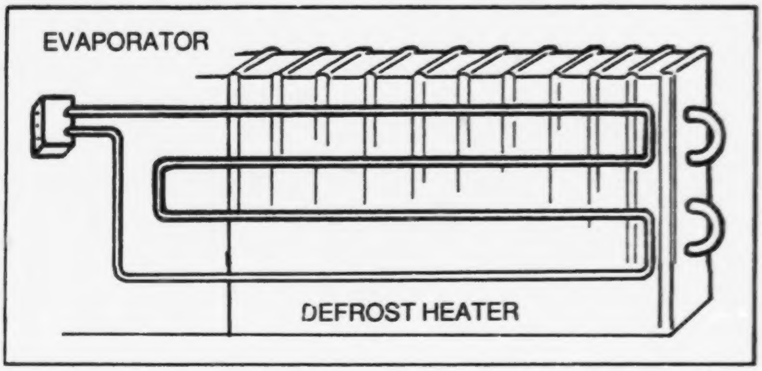
c. Run and start capacitors are usually shown by the same symbol; however, the run capacitor will have an asterisk at he designated terminal.


SYMBOL FOR A RUN CAPACITOR
*
SYMBOL FOR A START CAPACITOR

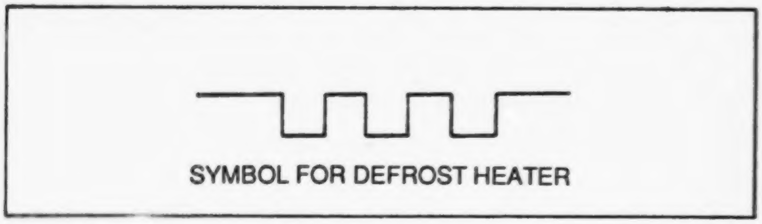
5. Defrost Heaters

a. Defrost heaters melt the frost that builds up on the evaporators of home refrigerators and freezers.

NOTE: Some defrost heaters are attached to the evaporator. Quartz-type heaters are usually located below the evaporator so the heat can travel upwards.


EVAPORATOR
DEFROST HEATER

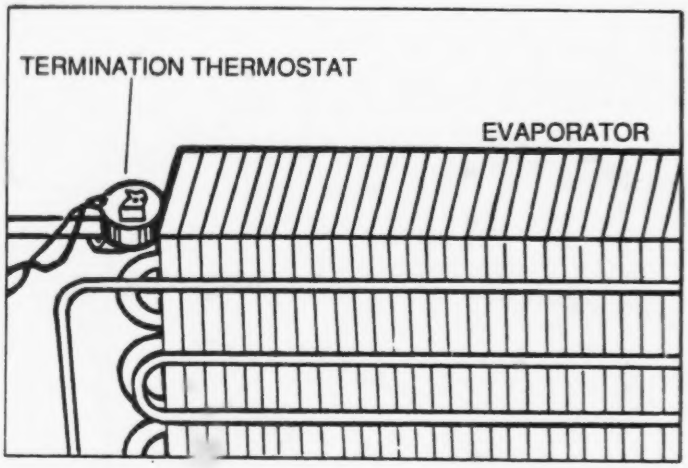
b. Here is the symbol for a defrost heater.


SYMBOL FOR DEFROST HEATER

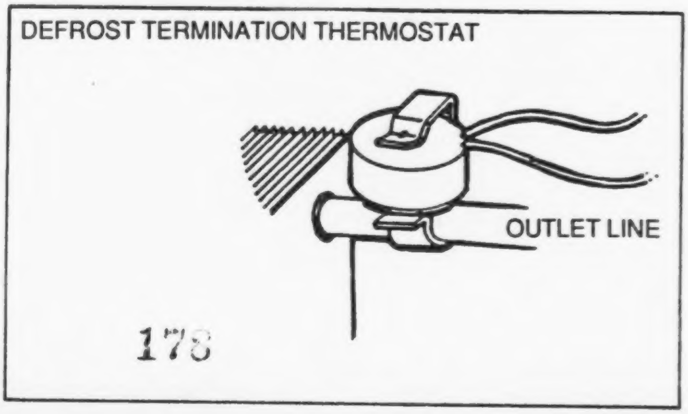
6. Defrost Termination Thermostats

a. A defrost termination thermostat turns off the defrost heater when the evaporator is warm enough for the frost to melt.

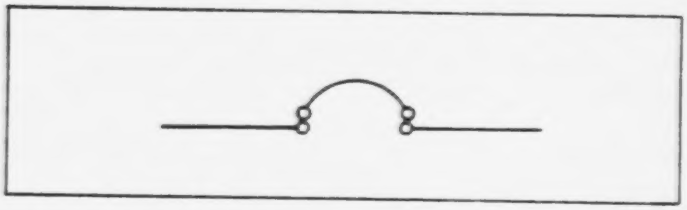
NOTE: It is located on or near the evaporator.


TERMINATION THERMOSTAT
EVAPORATOR

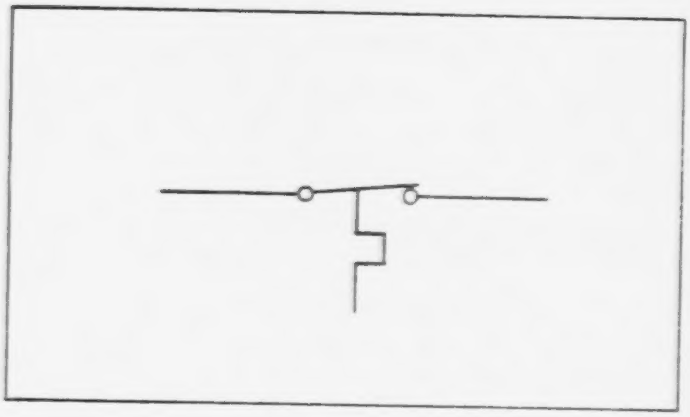
b. A defrost termination thermostat is a snap-action, bimetal disc much like the overload protector.


DEFROST TERMINATION THERMOSTAT
OUTLET LINE

c. Here is the most common symbol for a defrost termination thermostat.



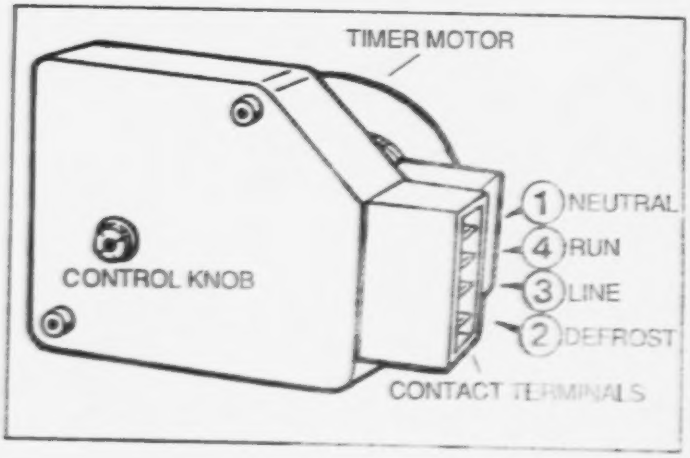
NOTE: A regular thermostat symbol could also be used.



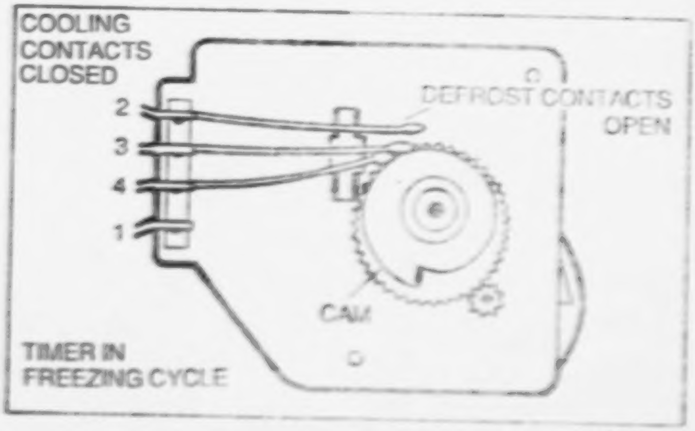
7. Defrost Timer

a. A defrost timer sets the refrigerator or freezer to run either its compressor or its defrost heater.

NOTE: In a typical defrost cycle, the compressor runs for six hours and then the defrost heater runs for twenty minutes. This cycle is repeated over and over.


TIMER MOTOR
① NEUTRAL
④ RUN
③ LINE
② DEFROST
CONTROL KNOB
CONTACT TERMINALS

b. The defrost timer is basically a clock that moves switch contacts instead of a set of hands. The position of the switch contacts makes the compressor or defrost heater work.

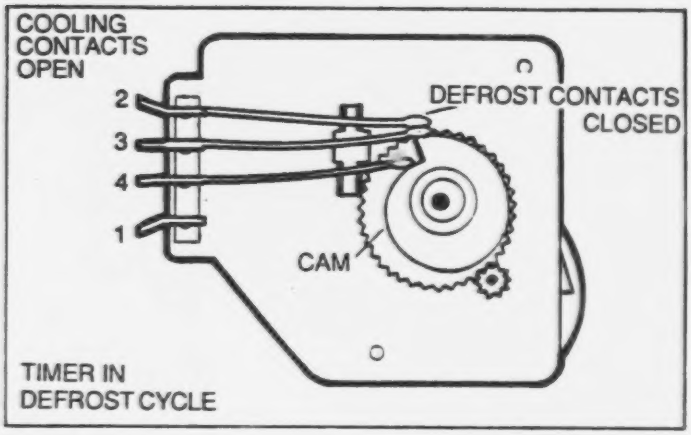

COOLING CONTACTS CLOSED
2
3
4
1
DEFROST CONTACTS OPEN
CAM
TIMER IN FREEZING CYCLE

c. Terminal 2 is normally connected to the defrost heater wire.

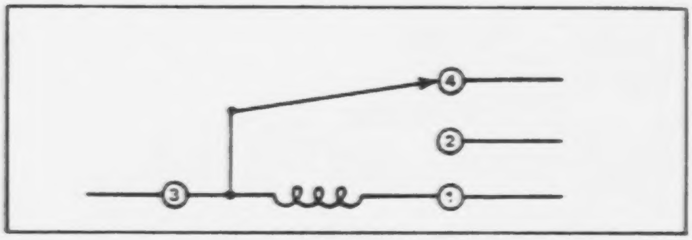
Terminal 3 is normally "hot" or line 1.

Terminal 4 goes to the compressor.

Terminal 1 is neutral.

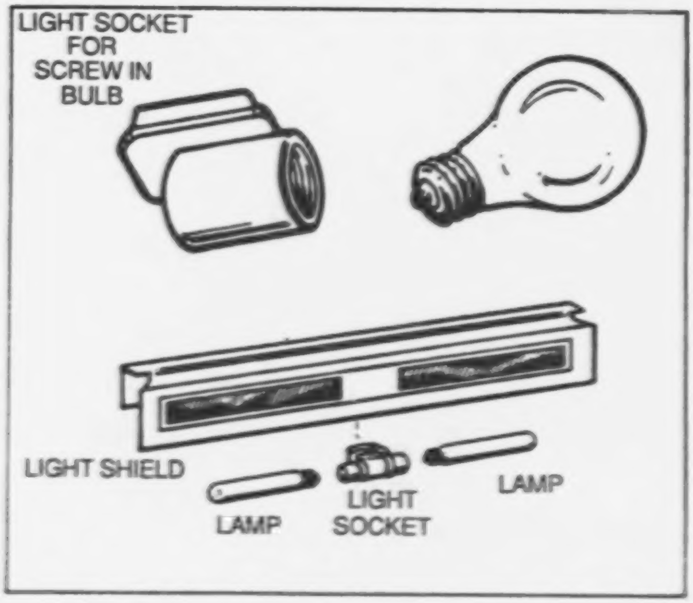

COOLING CONTACTS OPEN
2
3
4
1
DEFROST CONTACTS CLOSED
CAM
TIMER IN DEFROST CYCLE

c. This is the symbol for a defrost timer:

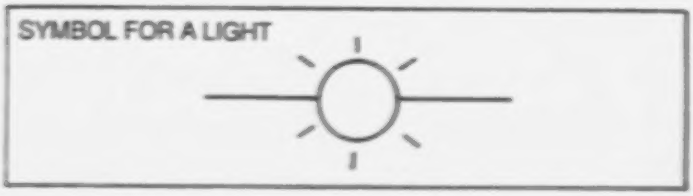


8. Lights

a. Two types of lights are used to allow a person to see inside a household refrigerator or freezer.

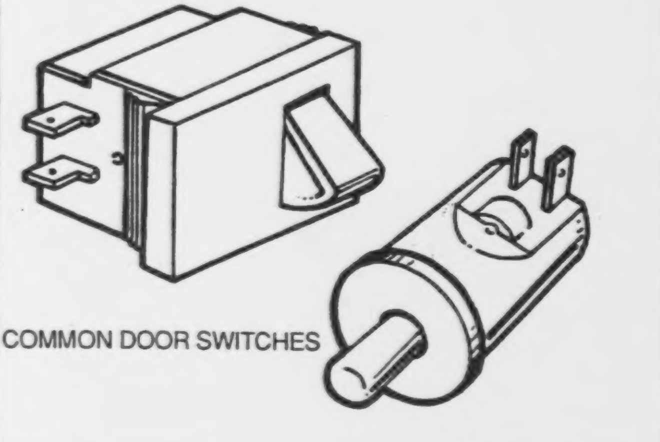

LIGHT SOCKET FOR SCREW IN BULB
LIGHT SHIELD
LAMP
LIGHT SOCKET
LAMP

b. This is the symbol for a light.


SYMBOL FOR A LIGHT

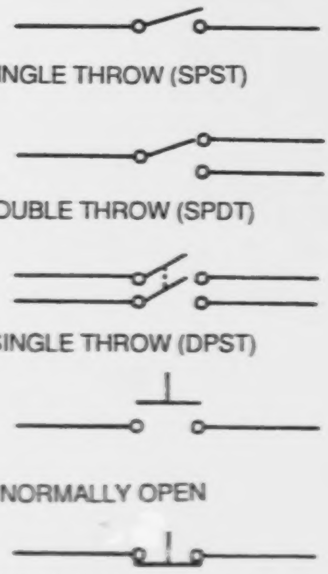
9. Switches

a. Switches are found on the doors of household refrigerators and freezers to control lights and fans.



COMMON DOOR SWITCHES

b. Several symbols may be used to show switches on a diagram.



SINGLE POLE SINGLE THROW (SPST)

SINGLE POLE DOUBLE THROW (SPDT)

DOUBLE POLE SINGLE THROW (DPST)

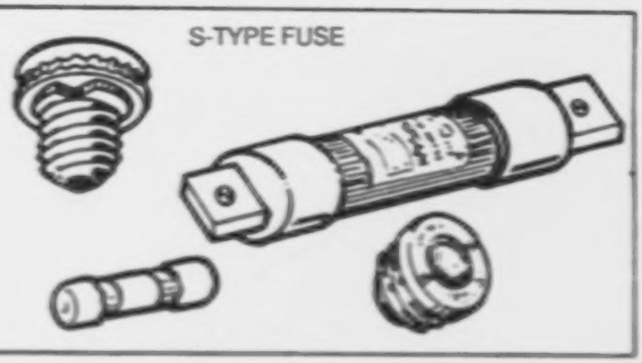
PUSH BUTTON - NORMALLY OPEN

PUSH BUTTON - NORMALLY CLOSED

10. Fuses

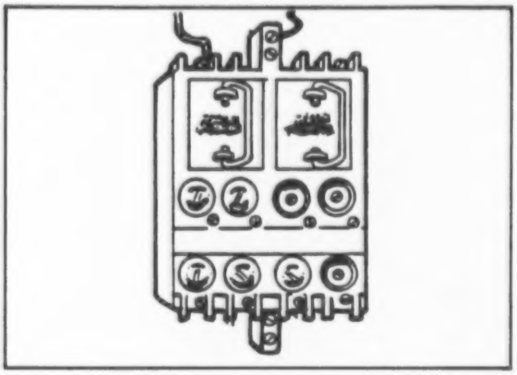
a. Fuses stop current flow when there is an overload or short circuit.

b. The "time delay" type of fuse is used on air conditioning and refrigeration equipment. Various sizes of S-type fuse cannot be interchanged with other fuses.

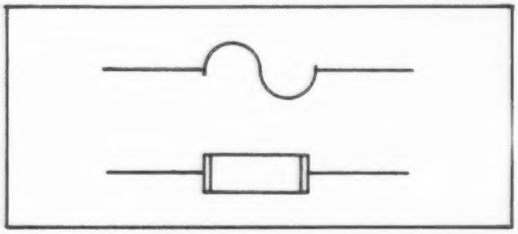


S-TYPE FUSE

c. Each electrical circuit in the system is protected by its own fuse. The fuses are located in the fuse box which is also called a load center.



d. This is the symbol used for a fuse on a drawing or diagram.



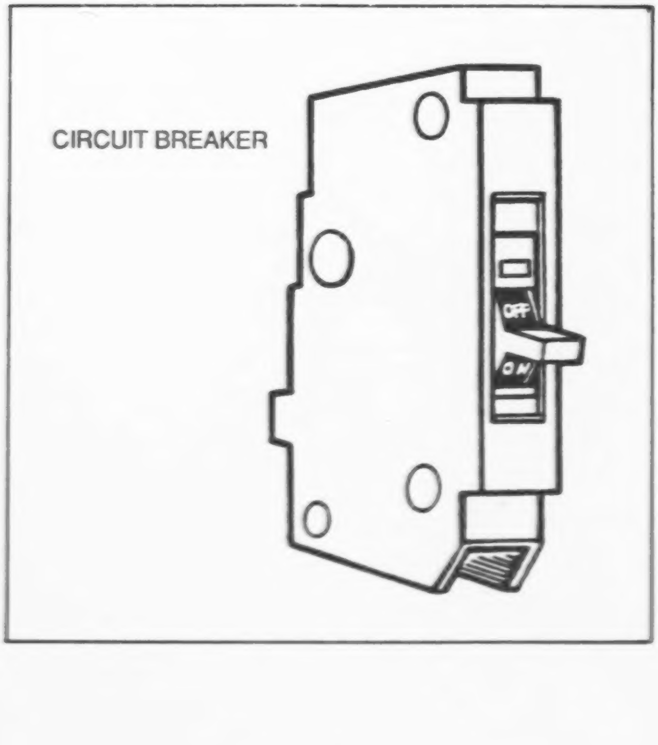
11. **Circuit Breakers**

a. Circuit breakers protect an electrical system from an overload or short circuit.

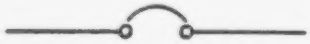
NOTE: A circuit breaker can be reset and used over and over, but a fuse can only be used once.

b. When a circuit breaker trips its switch, the current flow is stopped.

c. To reset a circuit breaker, pull the switch handle to the "off" position and then turn it back on.



d. This is the symbol for a circuit breaker.



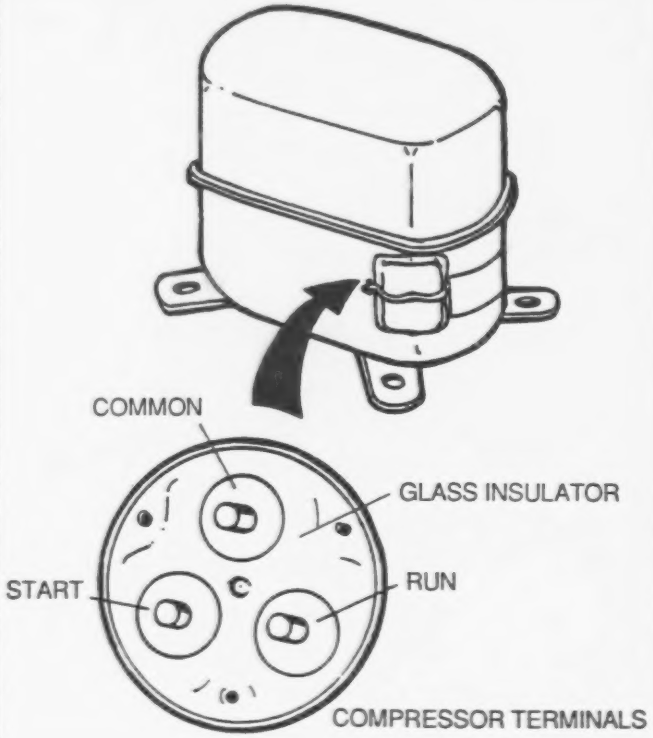
SYMBOL FOR A CIRCUIT BREAKER

12. Compressor Motor Terminals

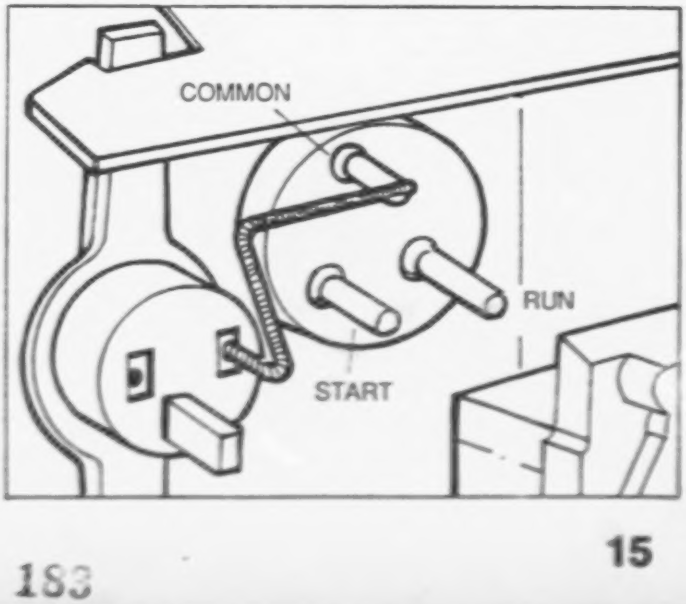
a. Compressor motor terminals are places where electrical connections are made.

b. The motor and compressor are placed inside a steel container and sealed shut. Motor windings are connected to three terminals that pass through the steel container.

CAUTION: NOT ALL MOTOR TERMINALS ARE ARRANGED AS SHOWN IN THIS DRAWING.

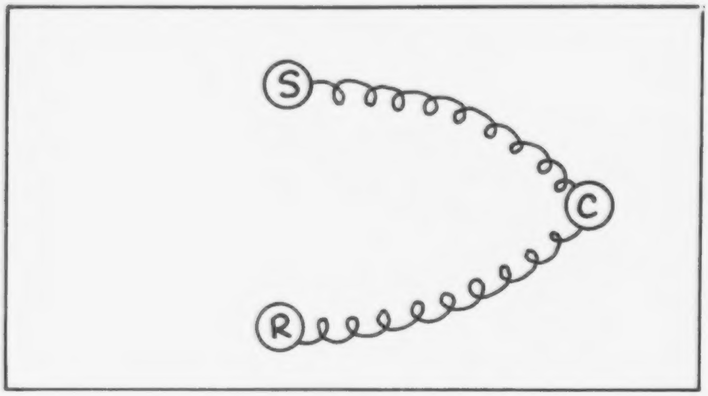

COMMON
GLASS INSULATOR
START
RUN
COMPRESSOR TERMINALS

c. The terminals are called the common, start, and run terminals. These terminals are not arranged the same on all compressors.

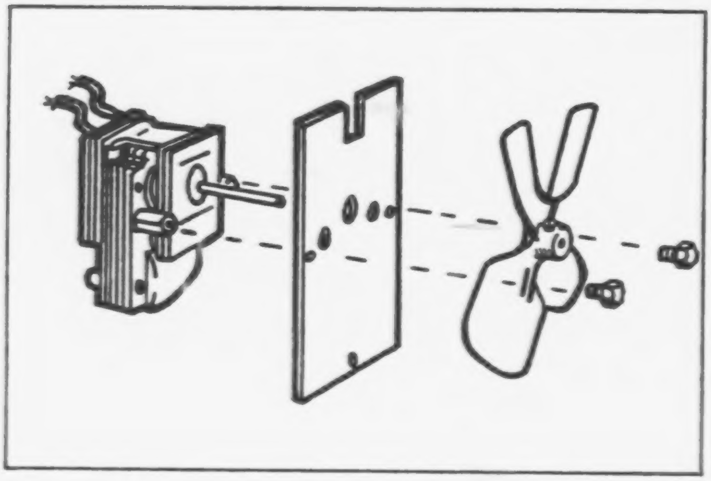

COMMON
RUN
START

CAUTION: If the electrical components are not connected to the correct terminals, the motor will be damaged.

d. The symbol for the compressor motor terminals shows how the windings are connected to the terminals.



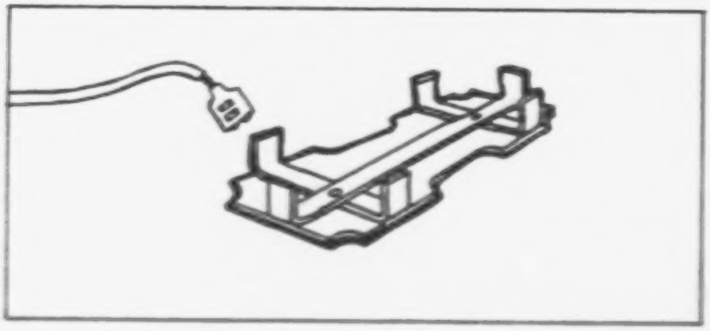
13. **Evaporator Fan**



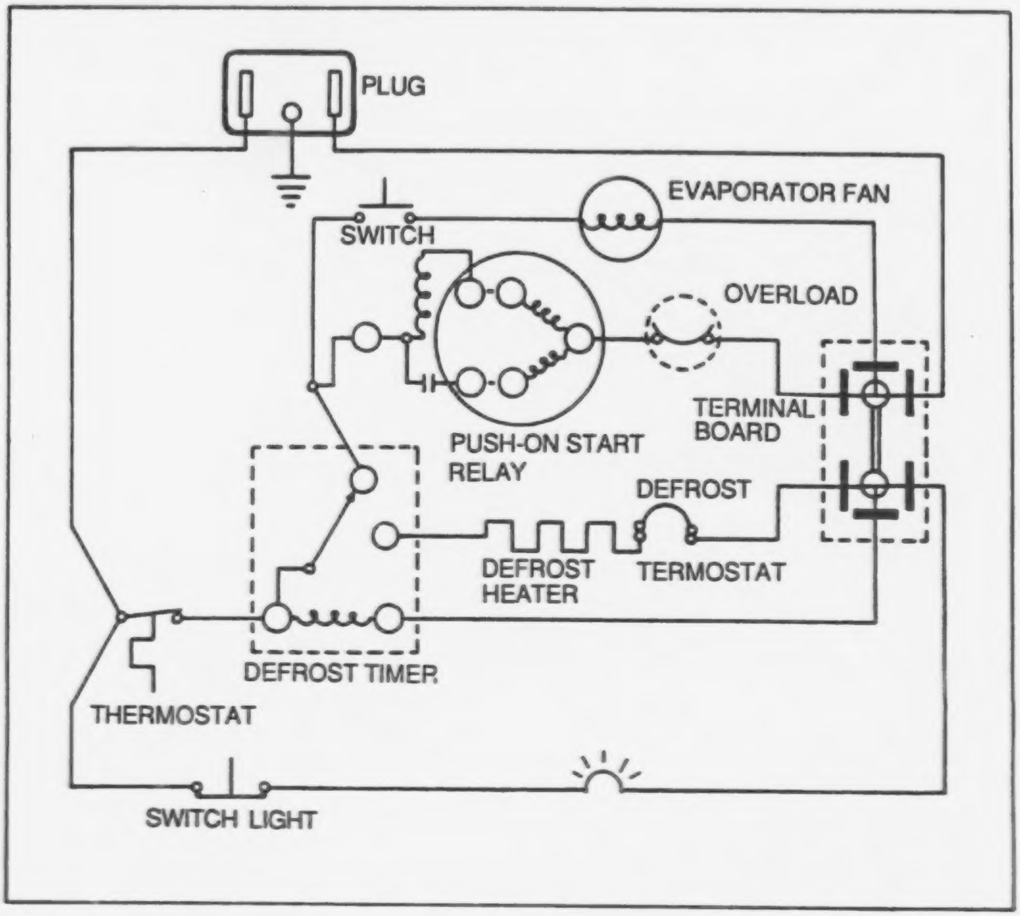
14. **Terminal Board**

a. The terminal board is the place where all of the neutral wires from the unit are connected.

NOTE: A gang plug is often used instead.



C. Steps of Procedure for Wiring a System


PLUG
EVAPORATOR FAN
SWITCH
OVERLOAD
TERMINAL BOARD
PUSH-ON START RELAY
DEFROST
DEFROST HEATER
TERMOSTAT
DEFROST TIMER
THERMOSTAT
SWITCH LIGHT

1. Assemble tools and equipment needed and obtain a wiring diagram of the system.

2. Identify each component used in the system by studying the symbols on the diagram.

3. Locate the components in the system to be wired.

4. Trace the wires on the drawing with the correct color of pen.

DO SKILL SHEETS 1, 2, AND 3.

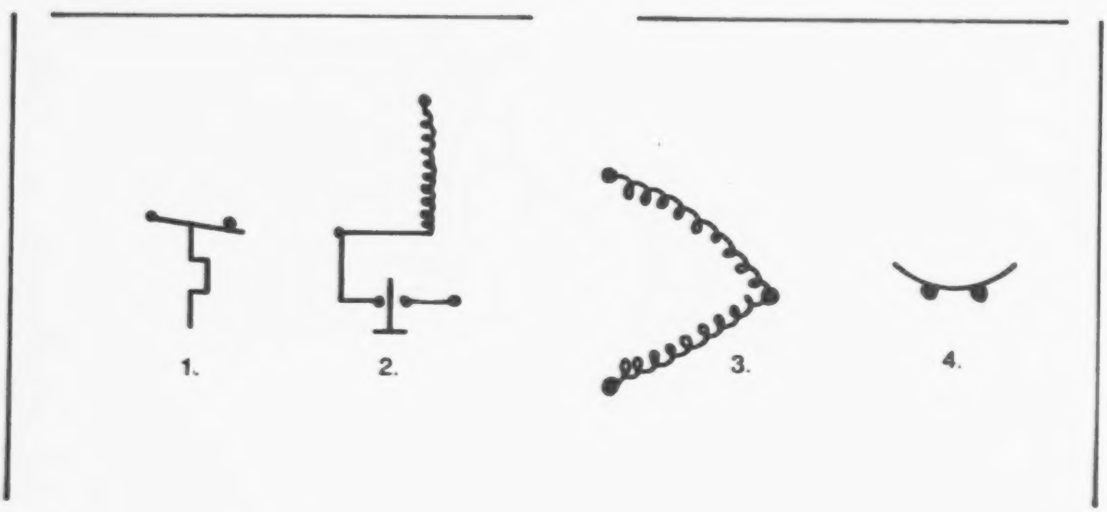
DO ACTIVITY SHEET 1.

ELECTRICAL COMPONENTS

SKILL SHEET 1

Directions: Study the following schematics and follow the instructions to complete each activity.

(NOTE: This activity may be used if wiring diagrams has been taught.)

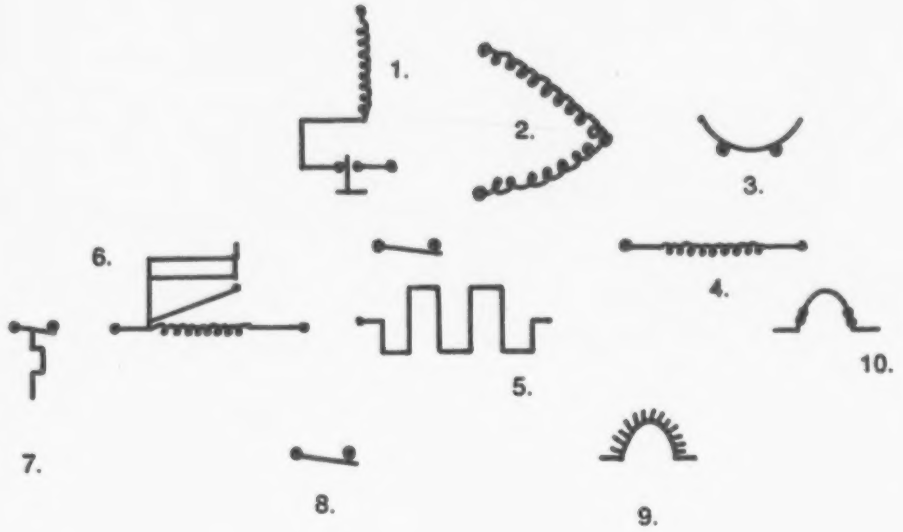


A. Connect the components in this ladder schematic so that the system would run.

B. List the names of the numbered components.

1. ____________ 2. ____________

3. ____________ 4. ____________



Compressor
Current Relay
Overload
Defrost Timer
Defrost Heater
Fan Switch
Light Switch
Fan Motor
Thermostat
Light
Defrost Termination Thermostat

A. Connect the above components so the system will run properly.

B. Name the numbered components. Use the list above.

1. ______ 2. ______

3. ______ 4. ______

5. ______ 6. ______

7. ______ 8. ______

9. ______ 10. ______

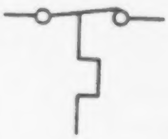
ELECTRICAL COMPONENTS

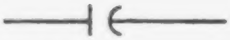
SKILL SHEET 2

Directions: Write the letter for each component in the blank beside its name.

____ 1. compressor motor terminal
____ 2. defrost timer
____ 3. defrost heater
____ 4. thermostat
____ 5. circuit breaker
____ 6. start relay
____ 7. start capacitor
____ 8. defrost termination thermostat
____ 9. overload protector
____ 10. switch
____ 11. light
____ 12. transformer
____ 13. fuse

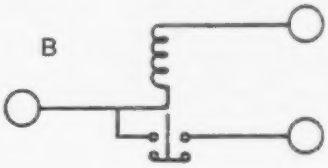
A

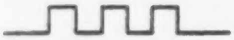




C

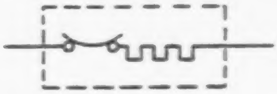
B



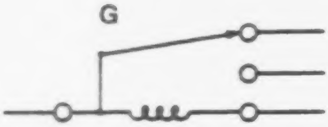


D

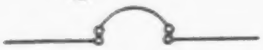
F

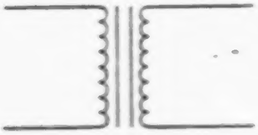


G



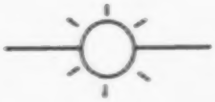
E



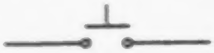


H

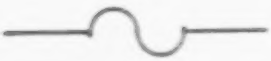
I



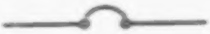
J



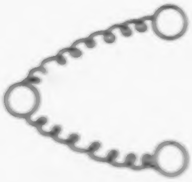
K



L



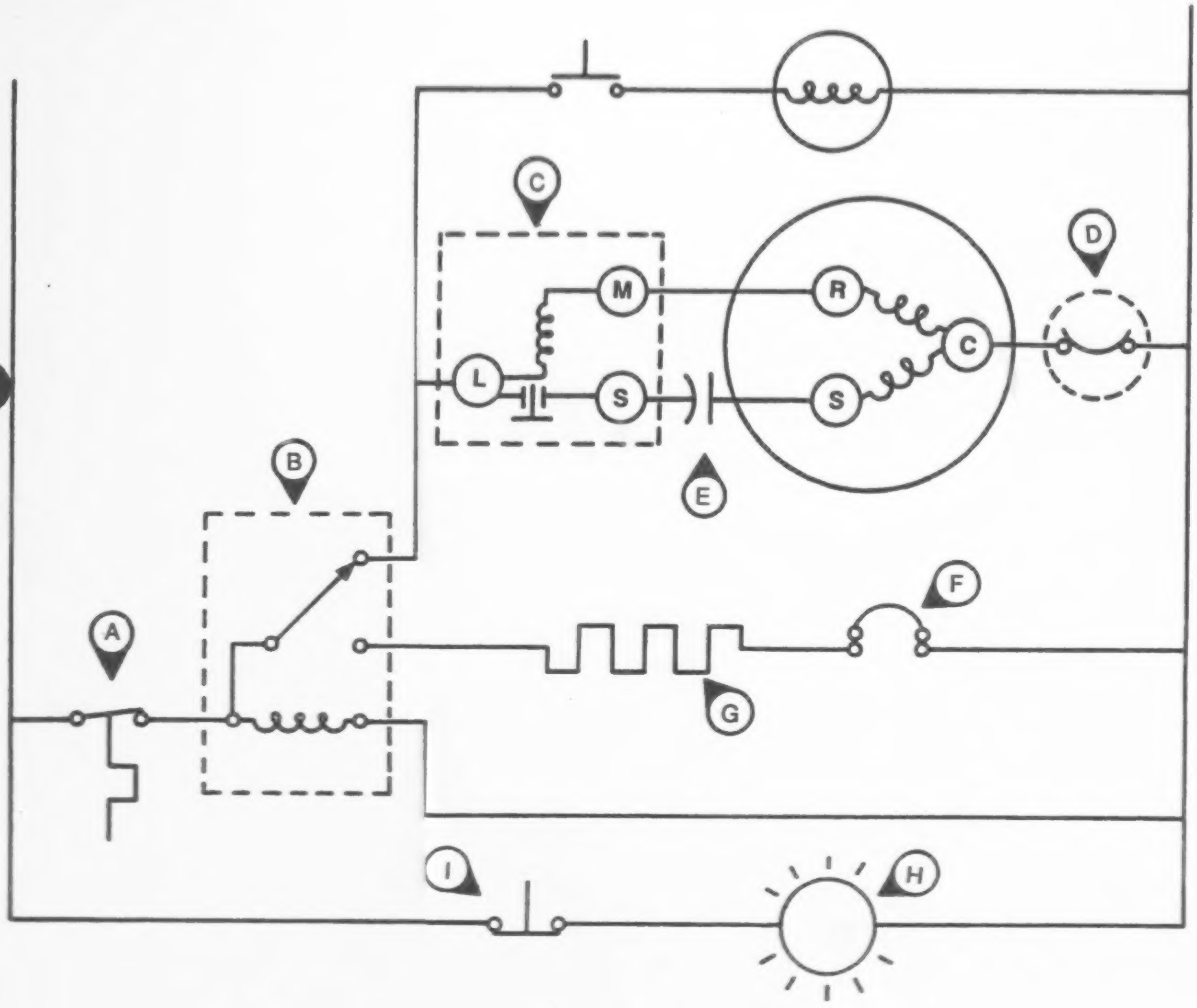
M



ELECTRICAL COMPONENTS

SKILL SHEET 3

Directions: Write the name of each symbol for the air conditioning components on this diagram.



A. ____________ B. ____________ C. ____________ D. ____________

E. ____________ F. ____________ G. ____________ H. ____________

I. ____________

ELECTRICAL COMPONENTS

ACTIVITY SHEET 1

Activity 1: Identifying Components

YOUR INSTRUCTOR WILL:

1. Provide a box of electrical components. Each component will be numbered.

YOU SHOULD:

1. Name each electrical component.
2. Explain the function of each component.

Activity 2: Examining a Wired System

YOUR INSTRUCTOR WILL:

1. Provide you with an air conditioning or refrigeration unit. All electrical wiring will be identified by numbers using wire markers.

2. Provide you with an electrical diagram of the unit. All wires on the diagram will be numbered to match the numbers on your unit.

YOU SHOULD:

1. Examine the unit and the diagram. Be sure you understand where each wire is found on the unit and on the diagram.

2. When you are ready, show your instructor the location of each wire on the unit and on the diagram.

3. After your instructor has removed some or all of the wires from the unit, use the diagram to reconnect the wires correctly.

4. Ask your instructor to check your work.

ELECTRICAL COMPONENTS

UNIT REVIEW

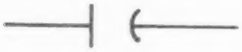
Directions: Read the following statements and choose the correct answer for each by circling the correct answer.

1. An electrical switch that is operated by a change in temperature is called a:

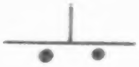
A. Transformer
B. Timer
C. Thermostat
D. Start Relay

2. A start relay is used to disconnect the power to the:

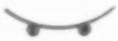
A. Start Winding
B. Common Terminal
C. Run Winding
D. Protector

3.  This is the symbol for:

A. Capacitor
B. Start Relay
C. Push Button Switch
D. Overload Protector

4.  This is the symbol for:

A. Capacitor
B. Start Relay
C. Push Button Switch
D. Overload Protector

5.  This can be used as a symbol for:

A. Capacitor
C. Start Relay
B. Push Button Switch
D. Overload Protector

6. The overload protector turns off the compressor if it becomes too:

A. Cold
B. Hot
C. Crowded
D. Fast

7. What component turns off a start capacitor?

A. Thermostat
B. Start Relay
C. Defrost Timer
D. Overload Protector

8. A component that melts the frost which builds up on the evaporator in a refrigerator is a:

A. Fuse
B. Terminal
C. Run Capacitor
D. Defrost Heater

9. Compressor motor terminals connect the motor with the:

A. Electricity
B. Start Relay
C. Light
D. Overload Protector

10. A component used to turn off the electricity in an overload or short circuit is a:

A. Transformer
B. Compressor
C. Evaporator
D. Fuse

11. A component which can be reset after an overload has occurred is a:

A. Transformer
B. Circuit Breaker
C. Fuse
D. Capacitor

12. A component used to turn a light or fan on and off is called a:

A. Switch
B. Fuse
C. Transformer
D. Start Relay

ELECTRICAL COMPONENTS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Identify the 14 basic components of air conditioning and refrigeration systems.			
2. Explain the function of each component.			
3. Identify the symbol for each component.			
4. Wire a system using these components.			

Satisfactory - Should Move On ☐

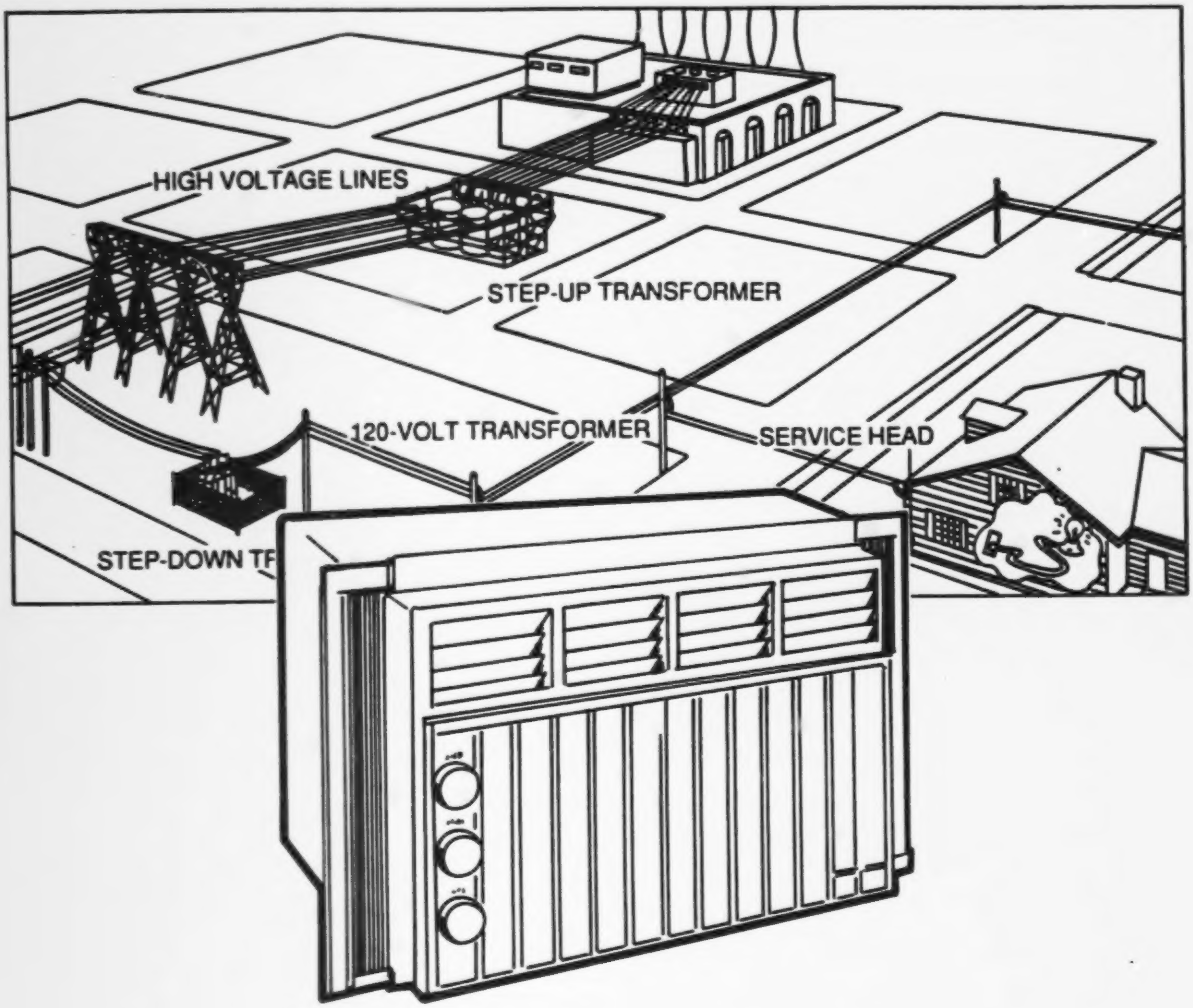
Repeat This Unit ☐

______________________________ ______________________________

Student's Signature/Date Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 6

Diagnosing Compressor Problems

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

DIAGNOSING COMPRESSOR PROBLEMS

INTRODUCTION

Often you will need to check hermetic and semi-hermetic compressors to determine if they are pumping properly or if the discharge valves are good. To do this, you must have a thorough understanding and knowledge of how the compressor works. You will also need skills in using refrigeration tools and instruments. In this unit you will learn how to "pinch off" or "valve off" the suction lines of refrigeration systems to check for faulty valves. The unit also shows how to return systems to service if the valves are good.

UNIT OBJECTIVE

After completing this unit, you should be able to identify hermetic and semi-hermetic compressors, diagnose and service compressor problems, and return compressors to operational status.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to:

1. Identify hermetic and semi-hermetic refrigeration compressors.
2. "Pinch off" the suction line or low side line to the compressor, causing the compressor to pull a vacuum on itself.
3. "Valve off" a semi-hermetic compressor suction line or low side line stem type service valve causing the compressor to pull a vacuum on itself.
4. Observe a hermetic and semi-hermetic compressor and refrigeration compound gauge to determine if the valves are leaking.
5. Demonstrate the ability to check a hermetic compressor to determine if valves are good.
6. Demonstrate the ability to check a semi-hermetic compressor to determine if valves are good.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

Terms

1. Ammeter - An electrical test instrument for the measurement of current flow.

2. Compressor - the pumping mechanism in a mechanical refrigeration system. It pulls a vacuum on the low or suction side of the system, pulling cool, low-pressure, heat-laden refrigerant back from the evaporator. It then compresses this low pressure vapor into a hot high-pressure vapor and discharges it into the condenser.

   a. Hermetic compressor - a compressor which has the motor sealed inside the steel compressor housing. The motor is cooled by the cool refrigerant vapor returning from the evaporator.

   b. Semi-hermetic compressor - a compressor which has the motor sealed in a bolted housing. It is also cooled by the cool refrigerant vapors returning from the evaporator. This type of compressor usually has stem-type service valves on the suction side and discharge lines.

3. Discharge line - carries the compressor hot, high-pressure discharge vapor from the compressor to the condenser. In domestic refrigeration, this tubing is usually constructed of steel. In commercial refrigeration, it is usually a copper tube.

4. Pinch-off tool - a specialized refrigeration tool used to compress or restrict refrigeration tubing. It is also used to remove the restriction made in the tubing.

5. Refrigeration gauge set - a specialized tool consisting of a compound gauge, pressure gauge, manifold with handles, hoses and hosehanger. It is used to measure temperatures and pressure of the refrigerant in the system. The compound gauge will also show the inches of vacuum the

system is running in, or the amount of vacuum being pulled by a vacuum pump. They can be used to pressurize, charge, purge and evacuate a refrigeration system using R-12, R-22 and R-502 refrigerant.

6. Refrigeration wrench - a specialized hand tool, usually a ratchet type. It is used to front seat, back seat and crack stem-type service valves easily and rapidly.

7. Stem-type service valves - hand valves that require a refrigeration wrench to open and close them. They are a permanent part of the system and have fittings for refrigeration hose connections.

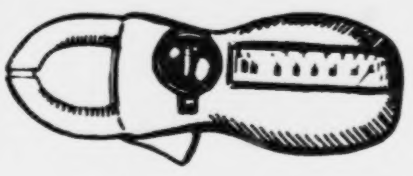
    a. Front seat - to turn a stem-type valve stem clockwise until it stops. This will close off the refrigerator line to the compressor.

    b. Back seat - turning a stem-type valve stem counter clockwise until it stops. This will close off the refrigeration line to the compressor.

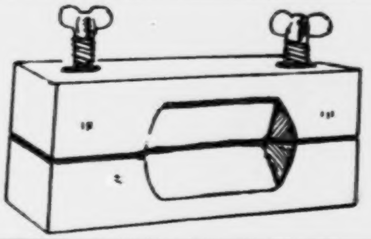
    c. Crack - turning a stem-type valve stem clockwise one-fourth to one full turn from the backseated position. This allows the technician to take pressure readings, evacuate a system, purge or add refrigerant.

8. Suction line - this is usually a copper tube which connects the outlet of the evaporator to the inlet of the compressor. It carries a cool, low-pressure, heat-laden refrigerant back to the compressor. The suction or low side line can usually be distinguished by its larger size from the high side lines. The suction line should be cooler to the touch. In the case of a domestic refrigerator, the capillary tube will be soldered to the suction line, using it as a heat exchanger.

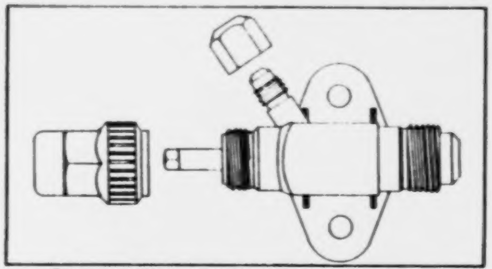
Equipment



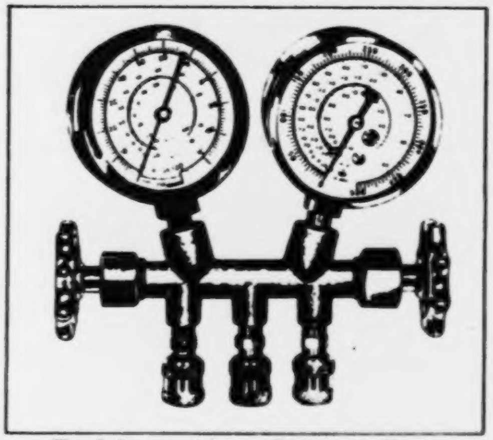
Ammeter



Pinch-Off Tool



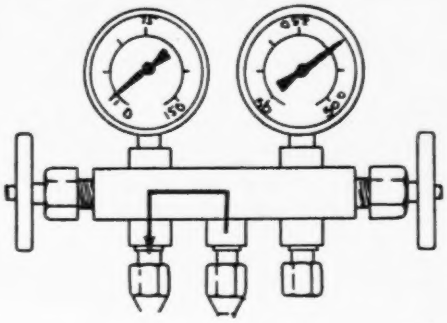
Stem-Type Service Valve

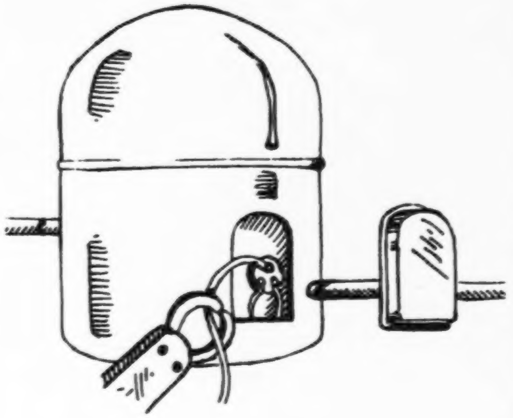


Refrigeration Gauge Set

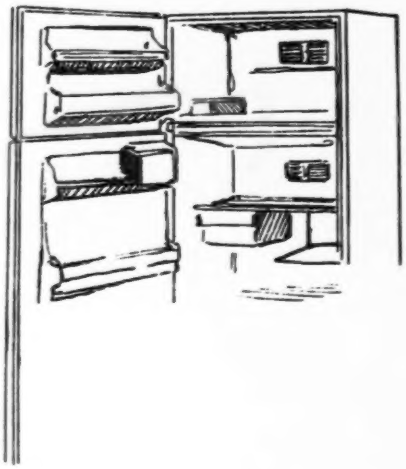
B. Symptoms of an Inefficient Compressor

1. Above normal suction pressure and below normal discharge pressure.



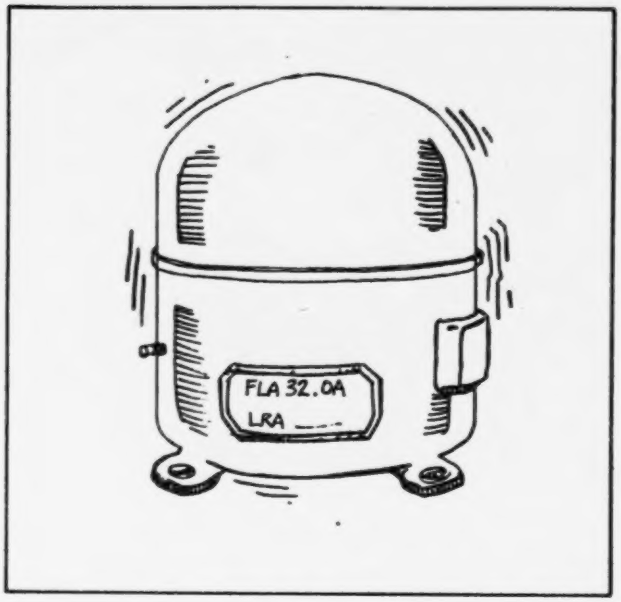


2. Below normal full load amperage



3. Unsatisfactory or above normal temperatures in the fresh food and freezer compartment

4. A fully frosted evaporator

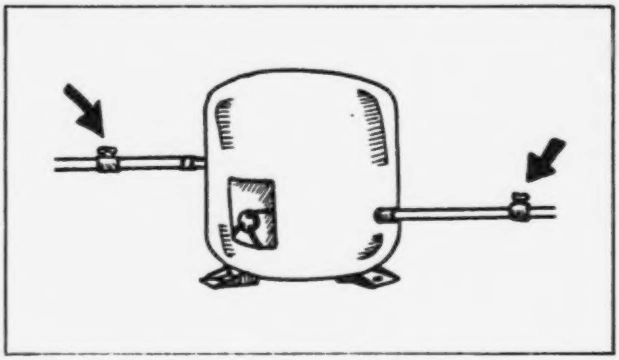

FLA 32.0A
LRA ___

5. A noisy compressor

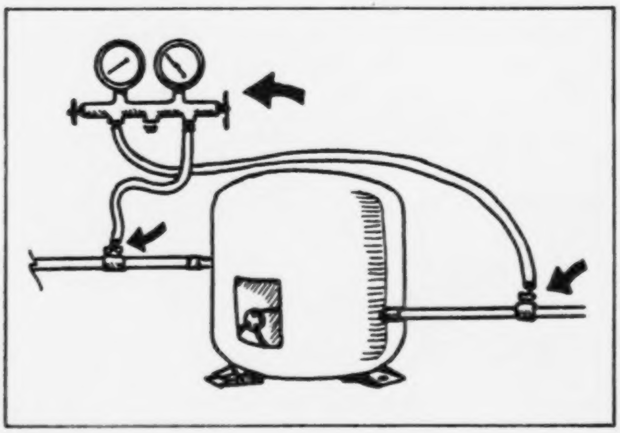
C. Checking for an Inefficient Compressor (Domestic Refrigeration)

Before starting these procedures, the technician must eliminate the possibility of other problems that show the same symptoms as an inefficient compressor.

1. PUT ON SAFETY GLASSES.

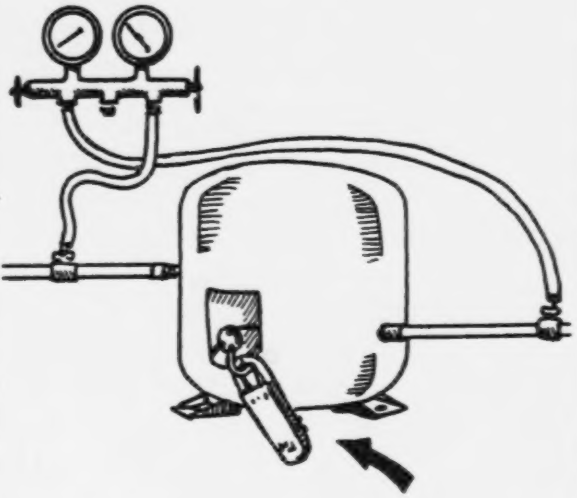


2. Install a line tap or schrader valve on the suction and discharge line, if one is not already installed. Be sure to clean dirt and corrosion from the line with sand cloth before installing the schrader or line tap.



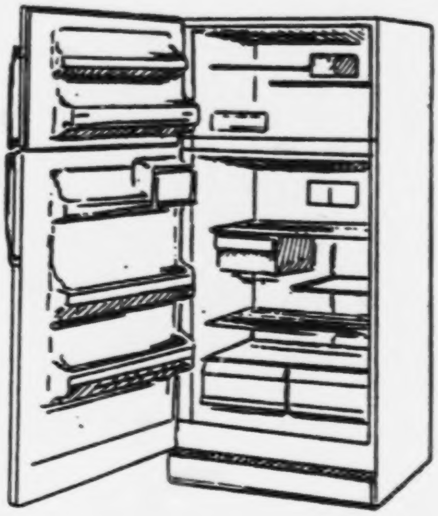
3. Attach refrigeration gauge set. Attach the compound gauge to the suction line and the pressure gauge to the discharge line. Remember that pressures are read with the manifold handles in the closed position.

4. Observe gauges and note pressures. If the pressures are above normal, use the ammeter to check the full load amperage (FLA). Obtain the FLA from the compressor or refrigerator data plate.



5. Check refrigerator fresh food and freezer compartment temperatures. This may be done by using a dial or electric thermometer.

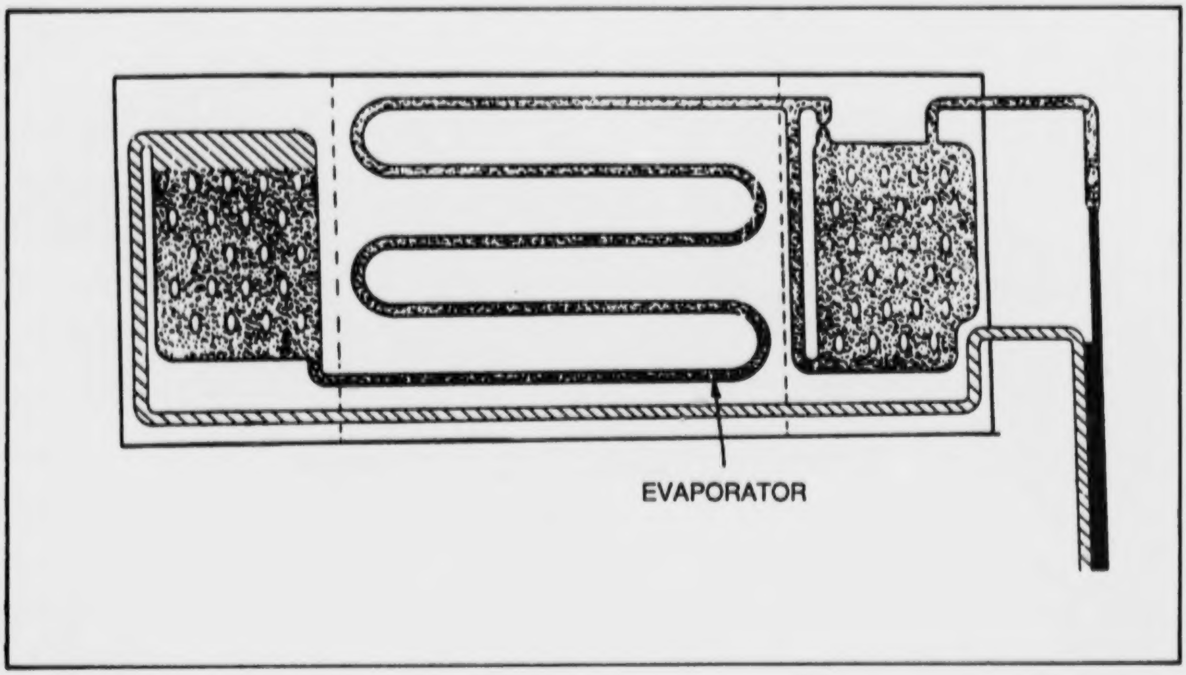
   (NOTE: If using a dial type thermometer to measure temperature, place it between two pieces of frozen food in the freezer compartment. In the fresh food compartment, wash thermometer in soapy water and take the temperature of a food product which has been stored in the compartment at least 12 hours.)



6. Finally, check the evaporator for a full frost pattern. If the refrigerator is a manual defrost, this can be observed without removing the cover panels.

   If there is an automatic defrost, the technician must remove the evaporator cover plate. Remove screws from plate to gain access to the evaporator.

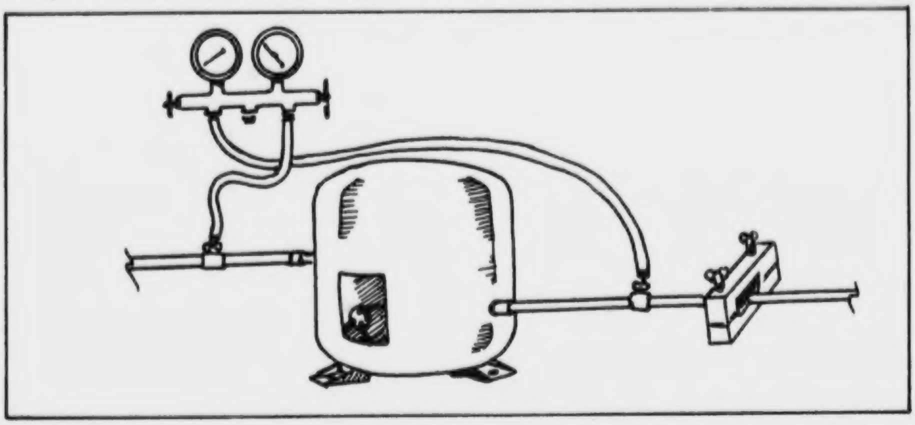
   Listen to the compressor for excessive noise or rattle.



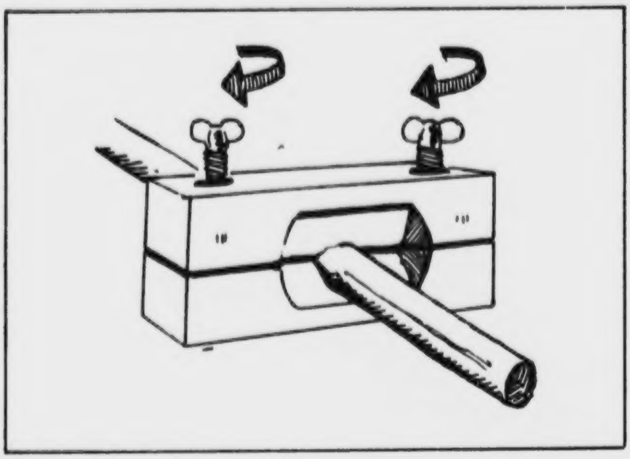
7. If all these symptoms appear, the technician will then proceed to check the compressor.

8. **PUT ON SAFETY GLASSES** and with the compressor running and refrigeration gauges on the system, obtain a block-type pinch-off tool. This is the only type pinch-off tool recommended for this procedure (however, other types may be used).

   Open the block. Place it on the suction line so that the schrader valve or line tap is between the compressor and the pinch-off tool.

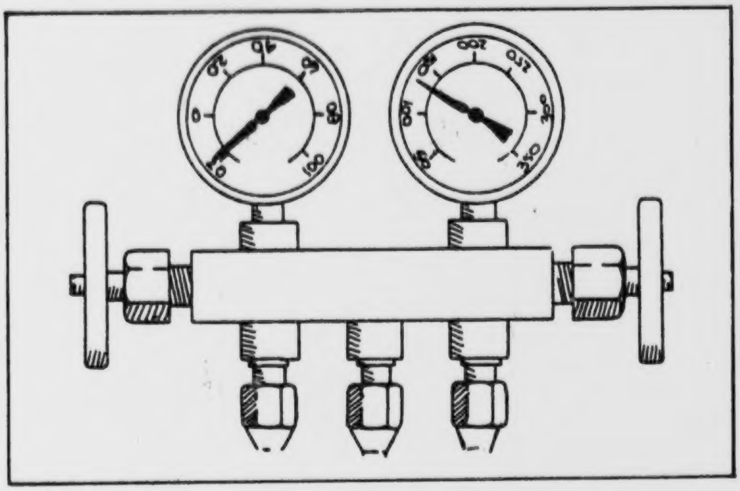


9. Tighten wing nuts evenly by first turning one nut two to three turns and then the other the same number of turns. Be sure the bevel portion of the block is on the suction line.



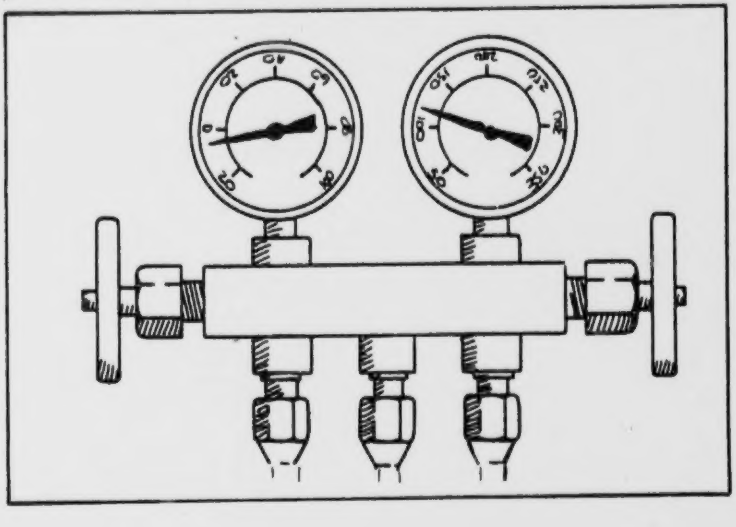
10. Continue to tighten wing nuts until tubing is completely collapsed by the bevel portion of the block.

11. Observe the compound gauge. It should pull into 15 to 25 inches of vacuum within 1 to 1 1/2 minutes after the line is completely pinched off.



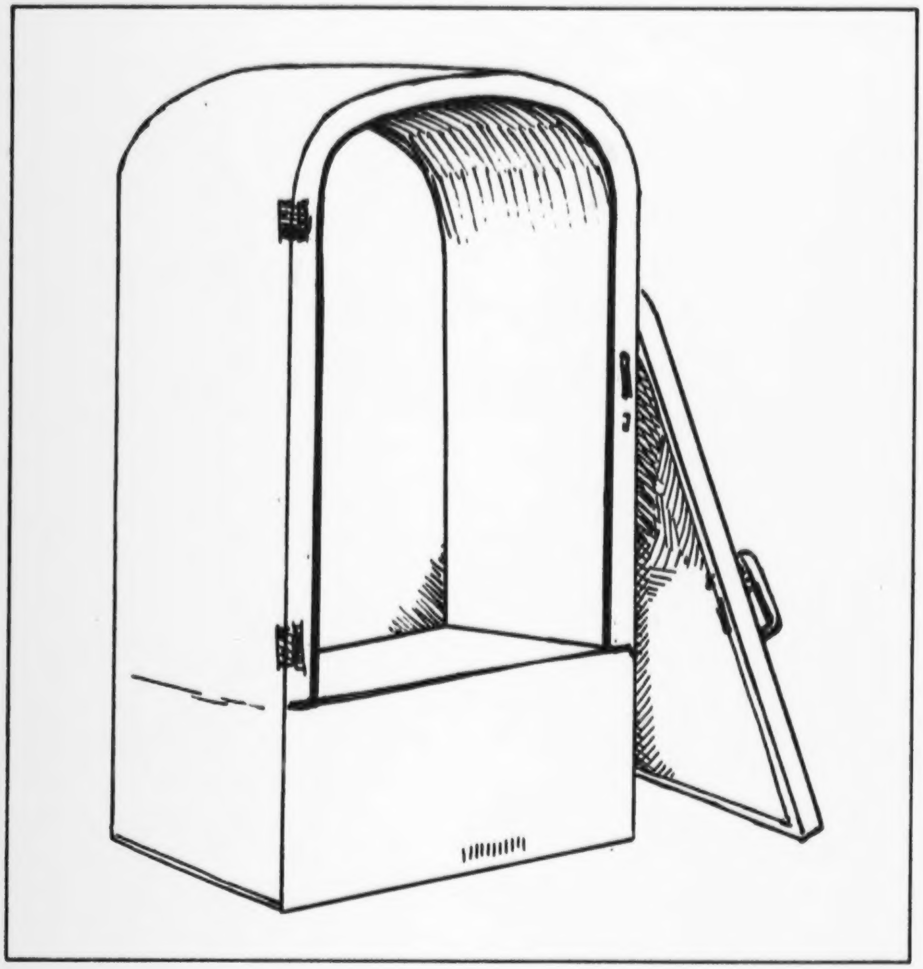
12. Unplug the refrigerator. It should hold the vacuum for approximately 2 minutes.

13. Usually, if the compressor has broken or burnt valves, the compressor will not pull down below 5 inches of vacuum, if that much.



14. If the compressor is inefficient, either a new compressor should be installed or the refrigerator should be destroyed. This depends on the age and condition of the cabinet.

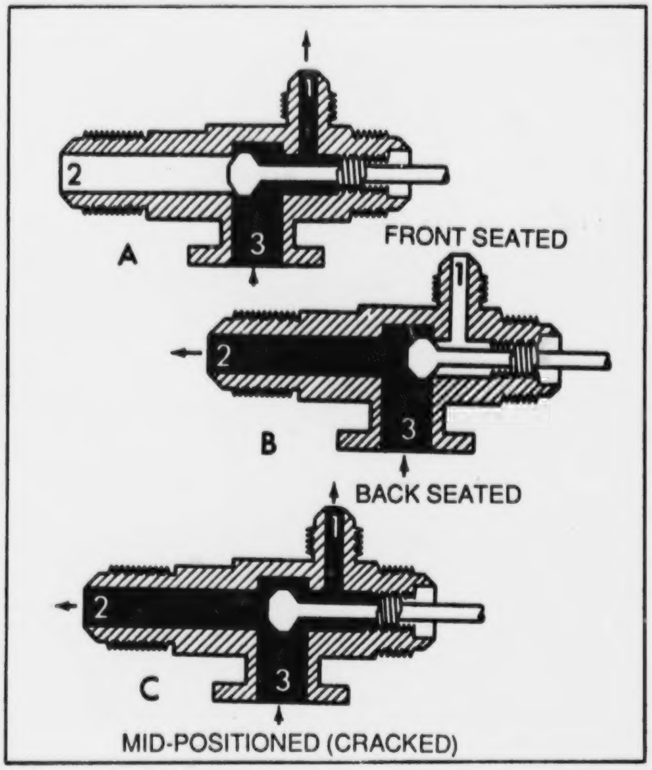
CAUTION: Remember, federal law requires that doors on refrigerators must be removed if they are being destroyed or discarded.



D. Checking for an Inefficient Semi-hermetic Compressor

A semi-hermetic compressor is checked in a much different manner than a hermetic compressor. There are stem-type service valves for the technician to use rather than line taps or schrader valves.

These service valves allow the technician to enter the system and isolate the compressor. Below are illustrations of the stem-type valve in the front seated, back seated, and cracked position.



Follow these steps to check a semi-hermetic compressor:

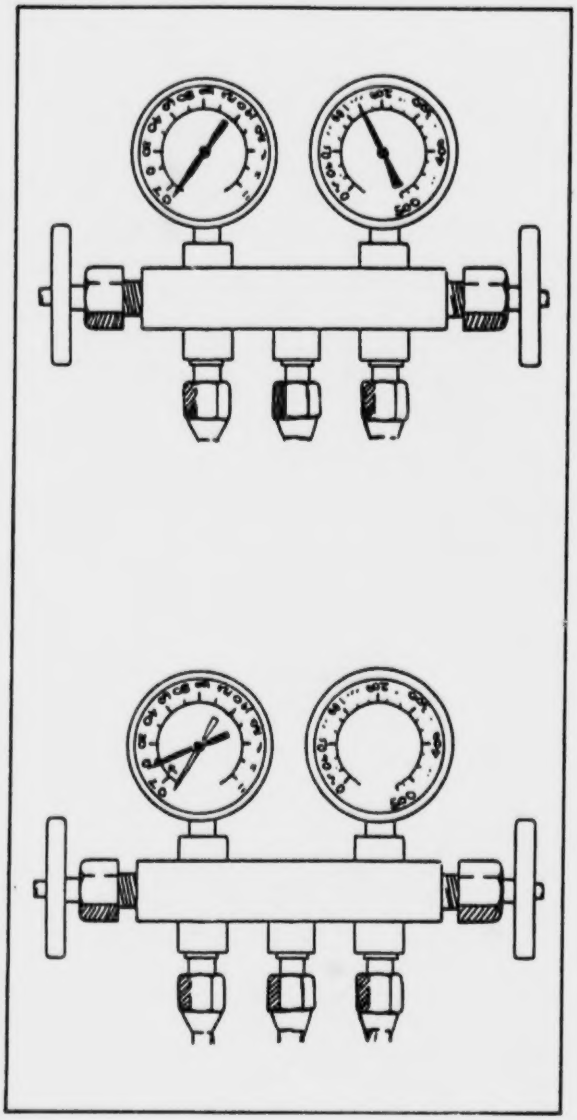
1. **PUT ON SAFETY GLASSES.**
2. Backseat the service valve stem on the suction line.
3. Install compound gauge service hose to the valve port.

4. With the compressor running, turn the suction service valve stem clockwise until it stops (front seat).

5. The compressor should pull down into a vacuum of 25 to 30 inches of vacuum. Turn the compressor off.

NOTE: DO NOT LEAVE THE COMPRESSOR RUNNING AFTER PULLING INTO A VACUUM. THIS COULD DAMAGE THE COMPRESSOR.

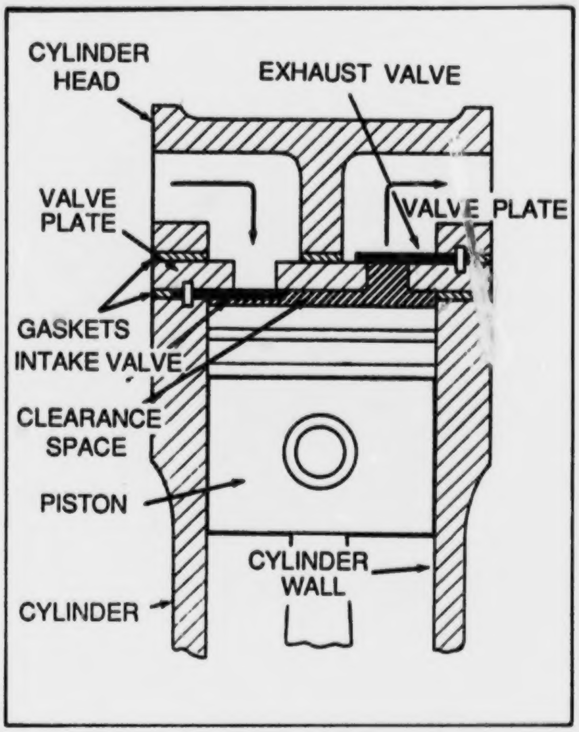
6. Observe the compound gauge. If the compressor valves are leaking, there will be a rapid rise of the compound gauge needle out of the vacuum.



7. If the compressor does have faulty valves, the compressor valve plate must be replaced.

8. If the problem is a broken piston or crankshaft, the compressor must be replaced.

9. If the compressor is operating satisfactorily, back seat the stem-type service valve and remove the refrigeration gauge set. Restart the compressor and look elsewhere for the problem.


CYLINDER HEAD
EXHAUST VALVE
VALVE PLATE
VALVE PLATE
GASKETS
INTAKE VALVE
CLEARANCE SPACE
PISTON
CYLINDER WALL
CYLINDER

DO ACTIVITY SHEETS 1 and 2

DO SKILL SHEET 1

DIAGNOSING COMPRESSOR PROBLEMS

ACTIVITY SHEET 1

CHECKING EFFICIENCY OF A HERMETIC

PUT ON SAFETY GLASSES.

1. Using a dial/stem-type, check the temperature of the freezer compartment. Be sure to place the thermometer between two pieces of frozen food or other articles in the freezer. You want the temperature of the food product, not of the air. Record the temperature.

2. Repeat the same procedure in the fresh food compartment, making sure you take the temperature of a food product that has been in the refrigerator for at least 12 hours. Be sure to wash the thermometer stem before placing it in the food. Excellent products to test are: jelly, pickles, mustard, and ham grease. Record the temperature.

3. Look at the frost pattern on the evaporator. If it is automatic electric resistance or hot gas, you will need to remove the evaporator plate. If it is manual defrost, you can observe it without removing plates or covers.

4. Use an ammeter to check the full load amperage (FLA) of the compressor. Record the amperage.

5. Listen to the compressor for excessive noise.

6. Suspect an inefficient compressor if you find:

   a. Above normal temperatures in the freezer compartment (15° to 25°F above 0°).

   b. Above normal temperatures in the fresh food compartment (44° to 55°F).

   c. A fully frosted evaporator.

   d. Below normal full load amperage and noisy compressor.

Proceed with the following steps.

7. Place a line tap or schrader valve on the suction or low side line.

8. Install a schrader-type valve on the discharge line.

9. Attach a refrigeration gauge set to the line taps or schrader valves. The compound gauge to the suction or low side and the pressure gauge to the discharge line.

10. Puncture lines.

11. Check compound and discharge pressures. Record these pressures.

12. If suction pressure and discharge pressures are above normal, proceed to step 13.

13. Obtain a block-type pinch-off tool.

14. Place pinch-off tool as close to the compressor as possible on the suction or low side line. Make sure the line tap or schrader valve is between the compressor and pinch-off tool.

15. Pinch the suction line or low side line closed by turning bat wing nuts to tighten. First tighten one end 2-3 turns and then the opposite end 2-3 turns. Continue with this process until the line is collapsed as much as possible.

16. With the suction line completely collapsed and the compressor running, it should pull down into 17 to 25 inches of vacuum. This should hold for 2 to 3 minutes, depending on how well you collapsed the tubing. Be sure to unplug the refrigerator as soon as lowest vacuum is pulled.

17. If the compressor fails to pull vacuum as described above, the valves are bad. They could be cracked or have foreign material under them, not allowing them to seat. The refrigerator must be condemned or a new compressor installed.

DIAGNOSING COMPRESSOR PROBLEMS

ACTIVITY SHEET 2

CHECKING EFFICIENCY OF A SEMI-HERMETIC

Customer's Complaint: Unit runs all the time, not cooling properly, compressor noisy, above normal temperatures.

1. **PUT ON SAFETY GLASSES.**
2. Start compressor.
3. Back seat both suction stem-type valve and the discharge stem-type service valve (if not already back seated).
4. Remove the dust cover or valve caps from the service ports on the valves.
5. Attach the compound gauge hose to the suction or low side valve port and the pressure gauge hose to the discharge valve port.
6. Crack the discharge stem-type valve by turning stem 1/4 to 1/2 and observe pressure reading.

7. Front seat the suction or low side stem-type service valve. This will stop the flow of refrigerant to the compressor.

   NOTE: NEVER FRONT SEAT THE DISCHARGE STEM-TYPE SERVICE VALVE WITH THE COMPRESSOR RUNNING. THE COMPRESSOR COULD EXPLODE AND YOU COULD BE INJURED.

8. Observe the compound gauge. It should pull down to 30 inches of vacuum. To keep the compressor running, it will be necessary to jump the low pressure control. As soon as the gauge needle stabilizes at 30 inches of vacuum, stop the compressor by shutting off the disconnect switch or by removing the jumper wire on the low pressure control.

9. The pressure may rise one or two inches on the compound gauge and stop. If the compressor valves are good, this pressure should hold indefinitely.

10. If valves are bad, the compressor will not maintain a vacuum. The pressures will continue to rise until they equalize.

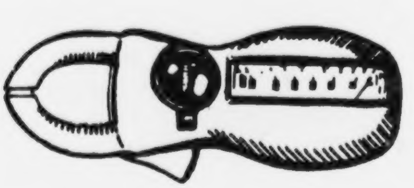
11. The compressor head and valve plate must be removed and a new valve plate installed.

    NOTE: Only semi-hermetics with a receiver or with oversized condensers are checked in this manner.

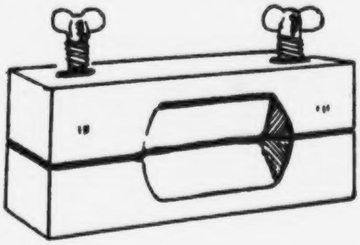
SKILL SHEET 1

Directions: In the blank beside each picture below, write the name of the item pictured. The items are all needed when diagnosing compressor problems.

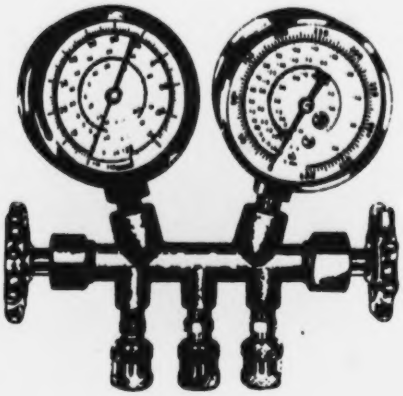
1. ______________________________



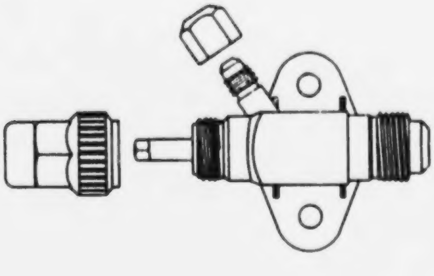
2. ______________________________



3. ______________________________



4. ______________________________



DIAGNOSING COMPRESSOR PROBLEMS

UNIT REVIEW

1. To front seat a stem-type service valve, the stem is turned ____________________ .

2. To back seat a stem-type service valve, the stem is turned ____________________ .

3. The ammeter is used to check the compressor's ____________________ ____________________ ____________________ .

4. List three symptoms of an inefficient compressor.

   a. ____________________________ .

   b. ____________________________ .

   c. ____________________________ .

5. Name the specialized tool used to collapse the suction line in checking an inefficient compressor. __________ .

6. A semi-hermetic with good valves should hold approximately ____________ to ______ inches of vacuum.

7. Match the proper term to the correct definition.

___ The pumping mechanisms of a refrigeration system. This pulls low pressure vapor back and discharges high pressure vapor.

___ Tubing usually constructed of copper. This connects the evaporator to the compressor.

___ Tubing usually constructed of steel on domestic refrigerators. It carries hot high pressure vapor from the compressor to the condenser.

___ A compressor with the motor sealed inside a welded compressor housing.

___ A compressor with the motor inside a bolted housing.

___ A specialized refrigeration tool used to restrict or collapse refrigeration tubing.

___ A specialized tool consisting of a compound gauge, pressure gauge, hoses and a manifold.

___ An electrical test instrument used to measure current flow.

a. Semi-hermetic

b. Hermetic

c. Ammeter

d. Compressor

e. Suction line or low side line

f. Refrigeration set gauge

g. Discharge line

h. Pinch off tool

DIAGNOSING COMPRESSOR PROBLEMS

PERFORMANCE CHECKLIST

Student ________________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
Hermetic Compressors			
1. Checked freezer temperature			
2. Checked fresh food compartment temperature			
3. Observed evaporator frost pattern			
4. Checked full load amperage			
5. Installed schrader valve on discharge line			
6. Installed schrader or line tap on suction line			
7. Installed refrigeration gauge set			
8. Pierced lines			
9. Read and recorded pressures			
10. Pinched off suction or low side line			
11. Observed compound gauge			
12. Made compressor diagnosis			
Semi-hermetic Compressors			
1. Checked temperatures			
2. Checked evaporator frost pattern (if a freezer)			
3. Checked full load amperage			
4. Back seated suction line stem-type service valve			

Procedure	Yes	No	Comments
5. Back seated discharge line stem-type service valve			
6. Removed service port caps			
7. Installed manifold gauge set			
8. Cracked suction line stem-type service valve			
9. Cracked discharge line stem-type service valve			
10. Observed and recorded pressures			
11. Front seated suction line stem-type service valve			
12. Jumped or shorted across pressure control			
13. Stopped compressor when optimum vacuum reached			
14. Observed compound gauge			
15. Made compressor diagnoses			

Satisfactory - Should Move On ☐

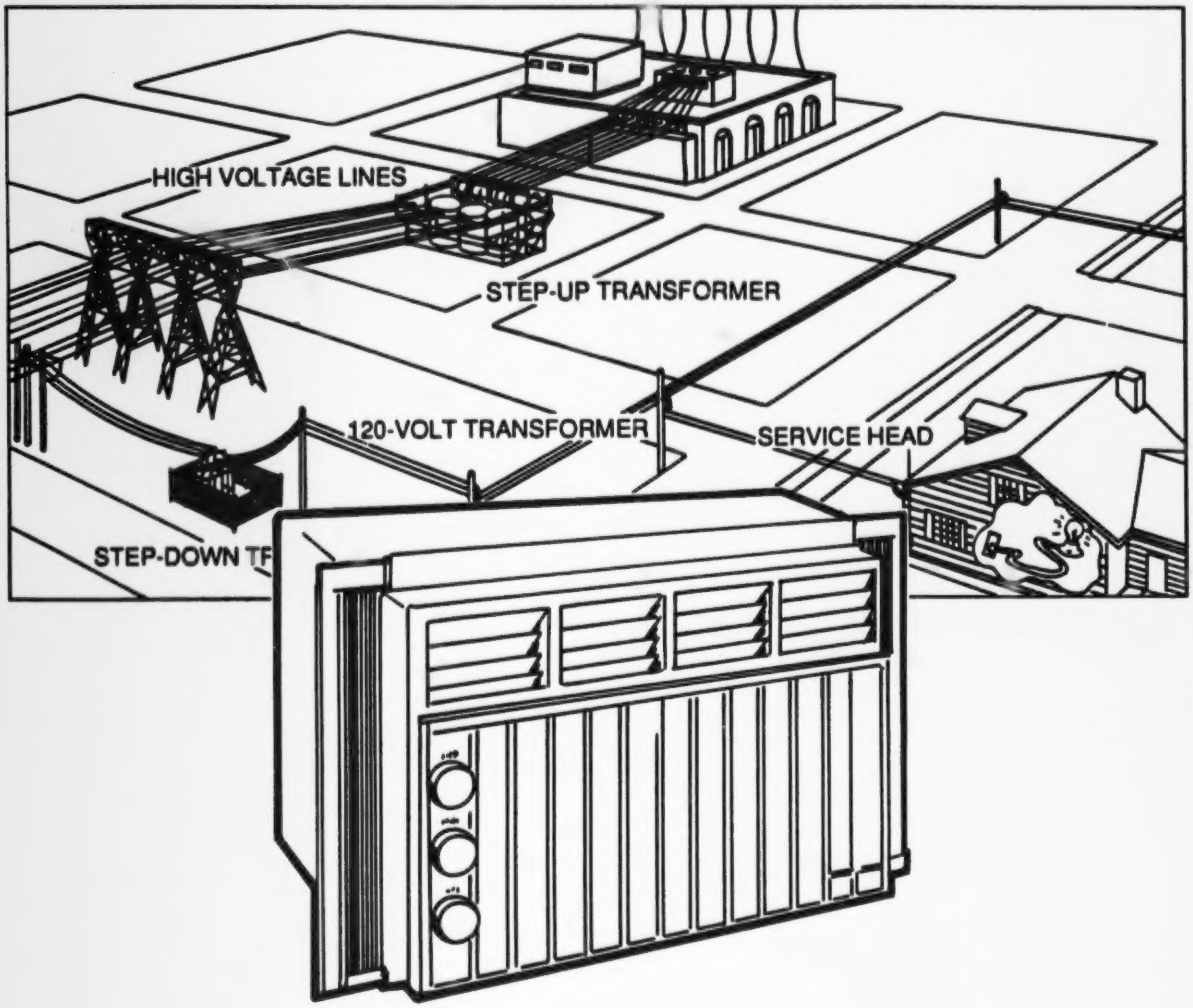
Repeat This Unit ☐

Student's Signature/Date

Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 7

Troubleshooting Mechanical Problems

in Domestic Refrigeration Systems

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

TROUBLESHOOTING MECHANICAL PROBLEMS IN DOMESTIC REFRIGERATION UNITS

INTRODUCTION

Troubleshooting is a logical process of checking a refrigeration system to see what is wrong with it. To troubleshoot any system, a person must know how the components work together. This unit will concentrate on mechanical problems that cause a refrigeration system not to work. Remember that a refrigerator causes cooling by removing heat.

(NOTE: A student must have satisfactorily completed a unit on the refrigeration cycle before attempting to troubleshoot a refrigeration system. It is suggested to use AC/R 85-150 :The Refrigeration Cycle," available through The Media Center, Sedalia, Mo.)

UNIT OBJECTIVES

After completion of this unit, you should be able to follow the three steps of troubleshooting: receive a complaint, check the system symptoms, review the symptoms to discover the causes of the problem and make the diagnosis.

SPECIFIC OBJECTIVES

1. List five symptoms for each of the five possible problems inside the refrigeration system: **overcharged, undercharged, inefficient compressor, restriction,** and **non-condensable gases.**
2. Identify tools used to gather information and determine symptoms.
3. Name all of the possible mechanical problems outside of the sealed refrigeration system.
4. Use a process of elimination to determine the system problem.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

Terms

1. Data - information, especially information that is used to make a decision.

2. Diagnosis - a decision that is made about a problem after looking at all the information on the situation and deciding what caused it.

3. Symptoms - signs that show something is not working normally.

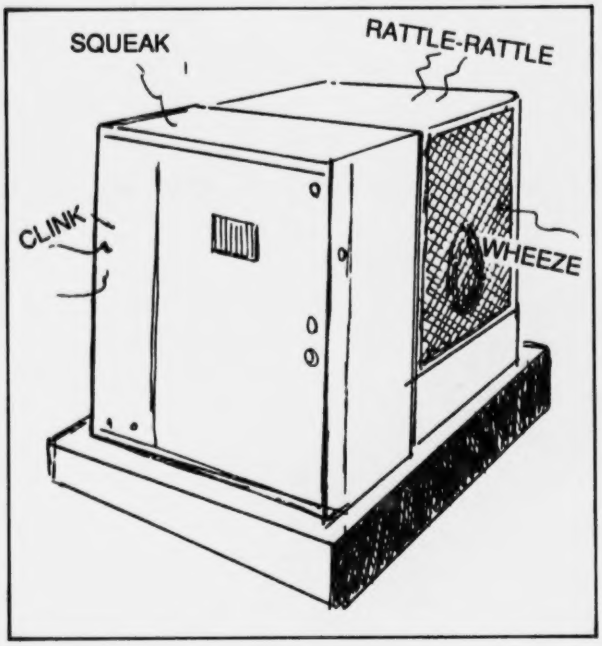
4. Troubleshooting - finding and repairing the causes of problems in mechanical equipment.

Equipment

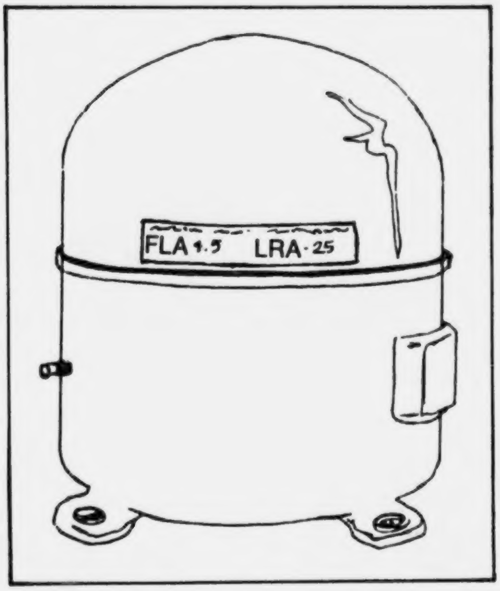
Flashlight
Flat Blade Screwdriver
Nutdriver
Phillips Screwdriver
Pliers
Clamp-around Ammeter
Line Tap Valve
Thermometer
Charging Manifold
Water Hose
Cleaning Solvent
Fin Comb
Wire Brush

B. Types of Mechanical Problems

1. Mechanical troubleshooting of a system must be divided into two parts: outside problems and inside problems. Problems that are considered **outside** of the sealed refrigeration system are components such as fans, condenser coils, evaporator coils, drains, air flow, and metering devices.



2. Problems that are considered as **inside** the sealed system are the parts that have refrigerant that flows through them. Examples are compressors, condensers, evaporators, metering devices, and connecting tubing.



3. Remember that you need to get all the symptoms that you can to make a diagnosis. Different problems may have many of the same symptoms, so you cannot make a diagnosis on just one or two symptoms. Also, a problem outside of the refrigeration system may have the same symptoms as an inside problem. This is why it is important to gather data to make a diagnosis.

CAUTION: NEVER ATTACH GAUGES AND ENTER THE REFRIGERATION SYSTEM UNTIL ALL OUTSIDE PROBLEMS HAVE BEEN REMOVED!

C. Troubleshooting an Outside, Mechanical Problem: Restricted Air Flow through a Condenser

Tools Needed:

Flashlight
Flat blade screwdriver
Nutdriver
Phillips screwdriver
Pliers
Clamp-around ammeter
Thermometer
Charging manifold
Water hose
Cleaning solvent
Fin comb
Wire brush

Many times outside problems can be located by a visual inspection--simply looking. But you must know where to look and what to look for.

A common problem is restricted air flow through a condenser coil. The customer **complaint** usually will be that the system runs but does not cool enough. This is a common complaint used for many problems.

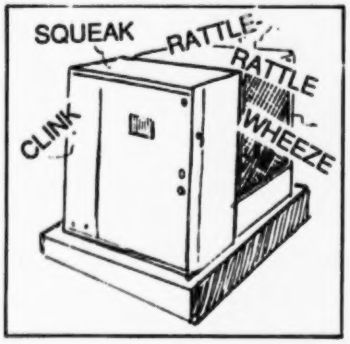
How will this cause the system to act, what will be the symptoms? Let's make a list:

1. High head and suction pressures
2. High amperage
3. Hotter than normal condenser
4. Not enough cooling
5. Extended run time of compressor
6. Compressor possibly shutting off on overload

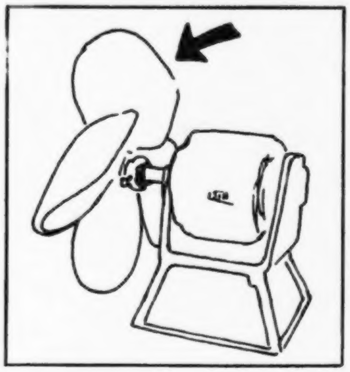
Steps of Procedure:

REMEMBER--DO NOT ENTER THE REFRIGERATION SYSTEM UNTIL NECESSARY! First collect data outside of the system and see if you can make a diagnosis without entering the system.

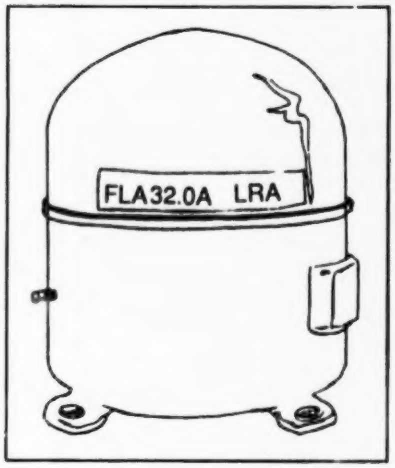
1. Listen to the system while running. Determine if anything sounds unusual.



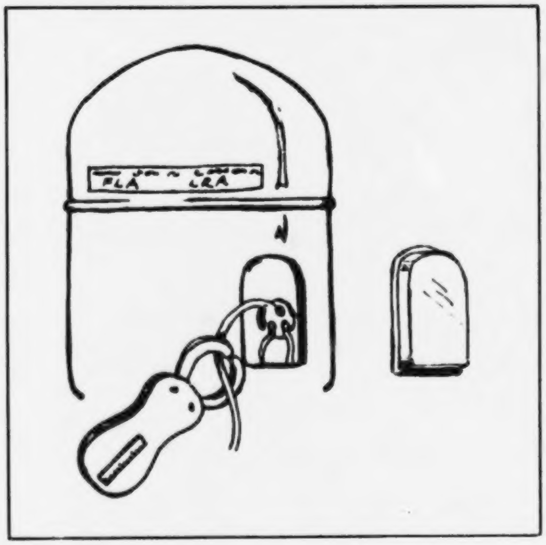
2. Look to see if the condenser fan is running.



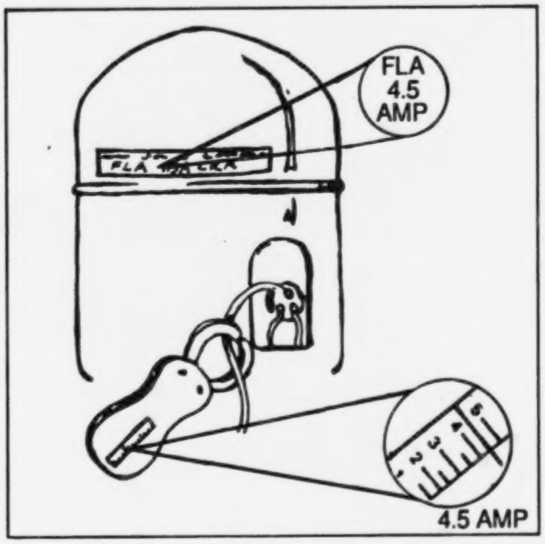
3. Determine the FLA amperage rating by reading the specification plate found on the compressor or cabinet.



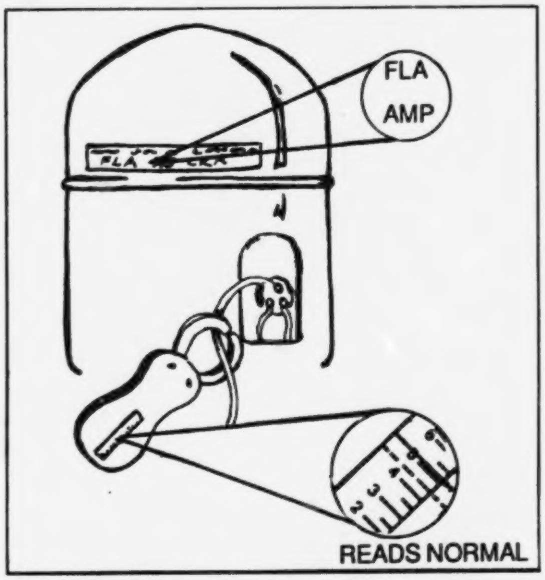
4. Using the clamp-around amprobe, check the operating amperage. You may need to remove a service door or plate to gain access to the compressor wires. The amprobe should be clamped around only one wire at a time.



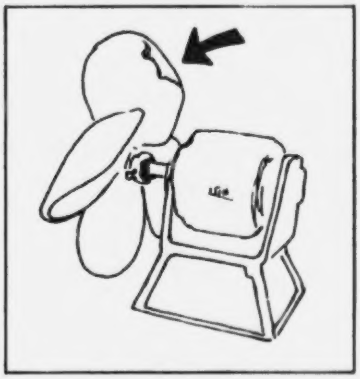
5. Compare the amperage reading with the normal operating or FLA rating.



6. If the amperage is too high, you can usually assume that the head and suction pressures are also too high. It may not be necessary to determine all of the symptoms at this time. Something is causing too high amperage and pressures.

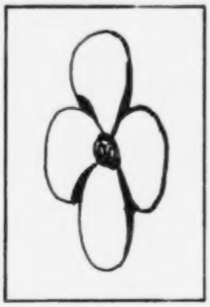


7. At this time, you should consider the things that could cause restricted air flow through the condenser coil, because this is a very likely problem. These may be bent fan blades, broken fan belt, fan motor inoperative, loose pulley, bent coil fins, or dirty condenser.

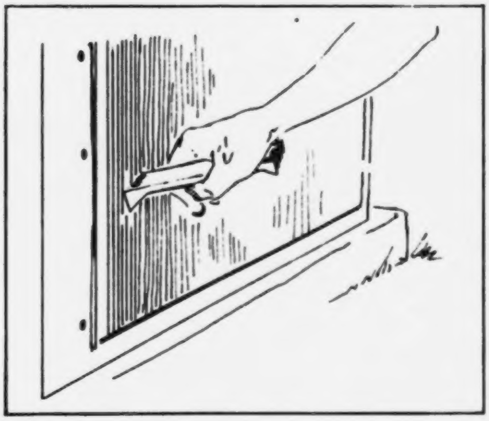


8. All of these can be determined by visual inspection--looking!

9. Bent fan blades can be repaired by straightening the blades by hand. But sometimes the blades will be out of balance and will cause a lot of vibration. In this case, a new fan may need to be installed.

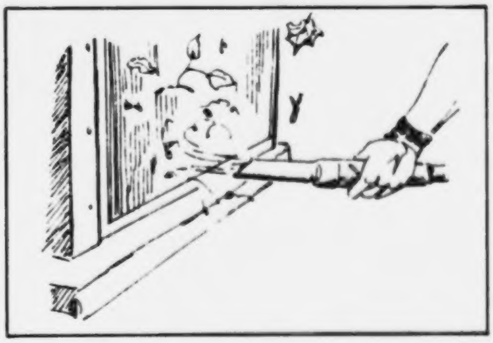


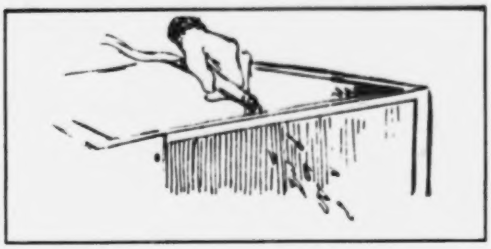
10. Bent coil fins can be straightened with the use of a fin comb. Be certain to use the correct comb. They come in different sizes according to the number of fins per inch.



11. A dirty condenser can be determined by looking at the coil in the same direction as the air flow. If in doubt about dirt causing the problem, clean the coil.

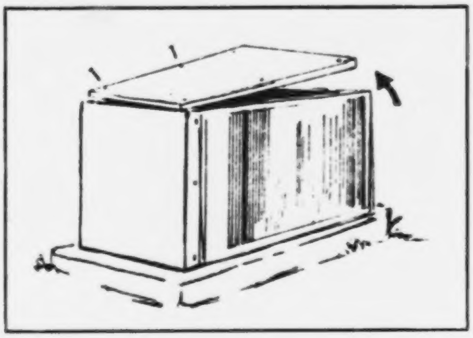
    Usually this can be done with a water hose. If the system is a refrigerator, you should use compressed air to blow out the dirt or a vacuum sweeper to suck out the dirt.



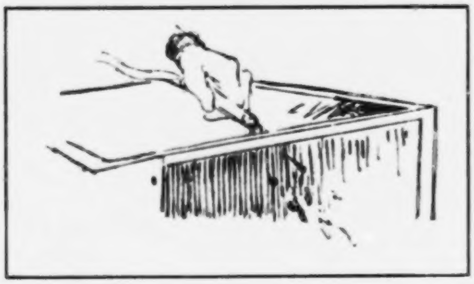


Cleaning an Outdoor Coil

CAUTION: DISCONNECT ALL ELECTRICAL SERVICE.



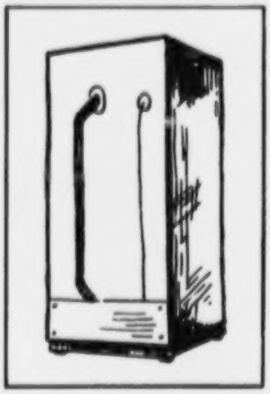
1. Remove top of cabinet or gain access to the coil.
2. Spray water down the edge of the coil.
3. After most of the dirt has been removed, spray water through the coil in the opposite direction of the air flow. Cover condenser fan motor with plastic to prevent water from entering the motor housing.
4. **BE SURE NO ELECTRICAL HAZARDS EXIST BEFORE RESTARTING THE SYSTEM.**



Cleaning a Domestic Refrigerator Condenser

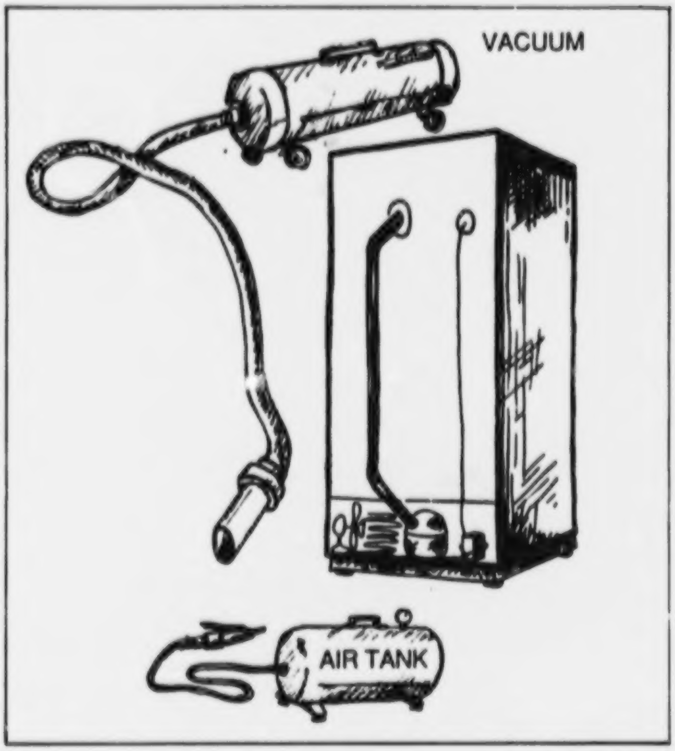
CAUTION: DISCONNECT ALL ELECTRICAL SERVICE.

1. Remove inspection panel to gain access to coil.



2. Use vacuum cleaner with crevice tool to remove lint and dirt.

3. If it is impossible to remove the dirt with the sweeper, compressed air can be used. Using compressed air will create a lot of dirt and dust in the air. Proper ventilation should be used.



4. Clean up any dust and dirt around the refrigerator. Replace the inspection panel and reposition the refrigerator as found. Be sure to allow adequate air flow around the sides.

D. Troubleshooting an Outside Mechanical Problem: Restricted Air Flow through the Evaporator

The customer complaint may be: not enough cooling and extended run time. If the system is a refrigerator, the lack of cooling will result in spoiled milk.

Symptoms:

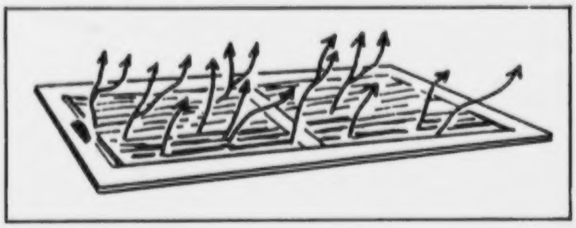
1. Low suction and head pressures
2. Evaporator covered with frost or ice
3. Suction line frosted or sweating
4. Low amperage
5. Cooler than normal condenser
6. The area to be cooled is warm
7. The compressor could be shutting off on an overload or low pressure control

The evaporator is located within the area to be cooled or in the duct delivering the cool air.

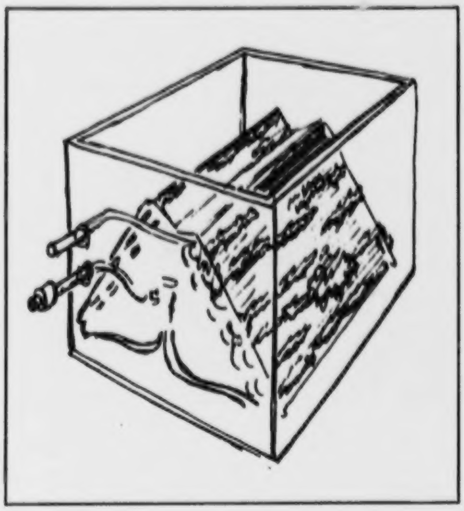
Restricted Air Flow in a Central Air Conditioning System.

1. Determine if the system is operating and feel for air flow out of registers and diffusers.

2. If very little or no air is felt, the problem can be mechanical or electrical. (This unit covers only mechanical problems.)

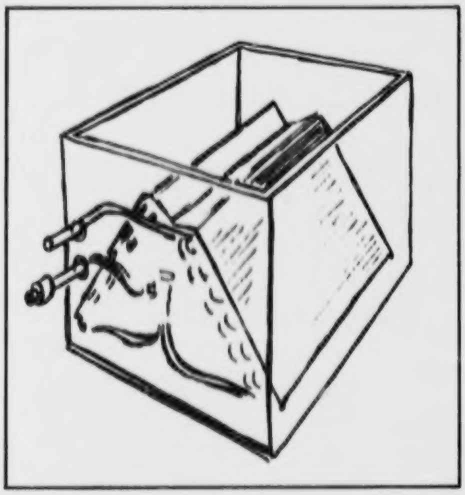


3. With the system operating, look for frost on the suction line. A frosted suction line can be caused by undercharge or overcharge of refrigerant. It could also be caused by restricted air flow through the evaporator.

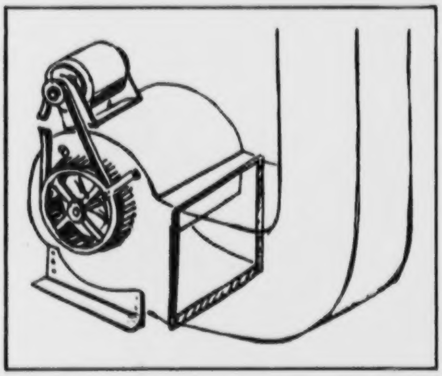


4. Because an overcharge and undercharge are inside the system, we will concentrate on restricted air flow.

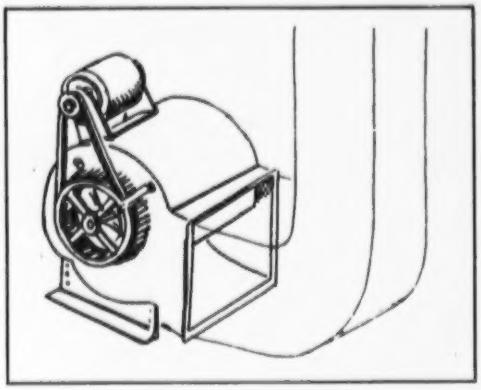
5. A central air conditioner uses the blower of the furnace to circulate air through the evaporator which is located on the top of the furnace and is sometimes referred to as an "A" coil.

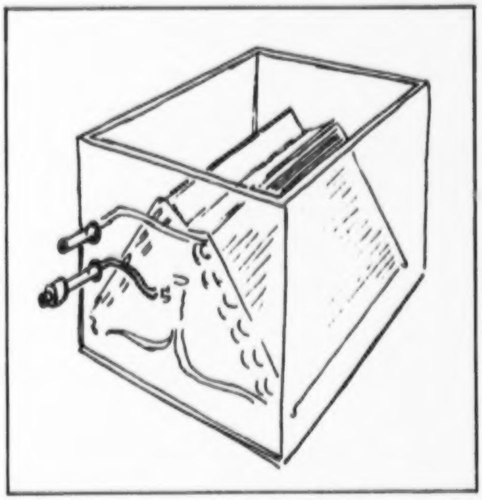


6. Remove the furnace blower compartment door and look for a broken belt, inoperative blower motor, and dirty filter.

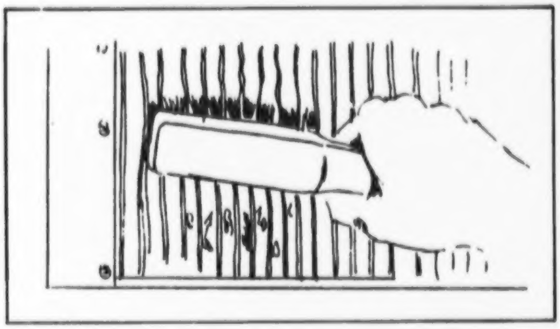


7. If everything in the blower compartment is okay, then you must visibly inspect the evaporator. To gain access to the evaporator, the installer should have made a door in the plenum (the ductwork on top of the furnace). The door is attached by sheetmetal screws.





8. Remove the screws, but leave the tubing attached to the coil. The drain may be removed if necessary. You only need enough room at this time to use a flashlight. Look at the inside of the evaporator to determine if it is stopped up with dirt.

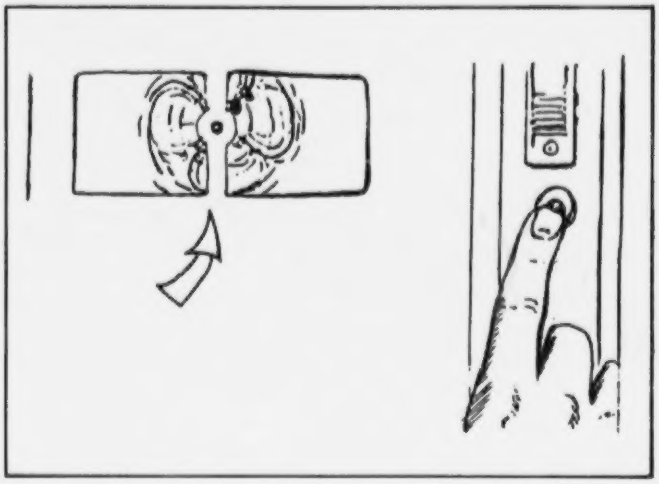


9. If the evaporator is dirty, it can usually be cleaned with a wire brush. It may be necessary to remove the evaporator from the plenum. But this should be done only as a last resort, because refrigerant will be lost and contamination will get inside the system.

Restricted Air Flow in a Refrigerator

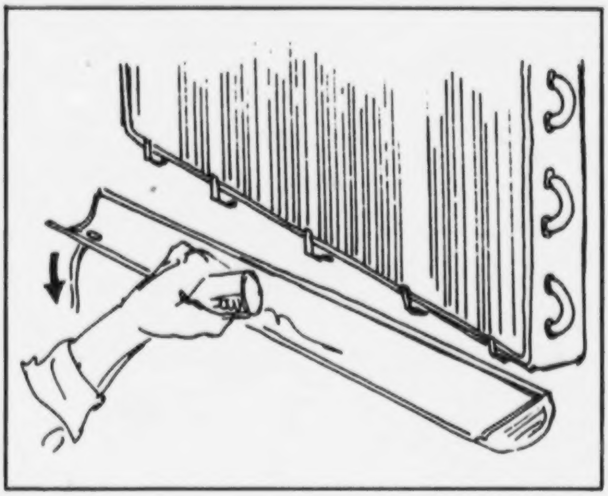
1. The evaporator and fan are located in the freezer compartment.

2. Open the freezer door, push in on the freezer fan door switch, and observe the fan operation. If the fan is not running, it can be due to a mechanical or electrical problem.

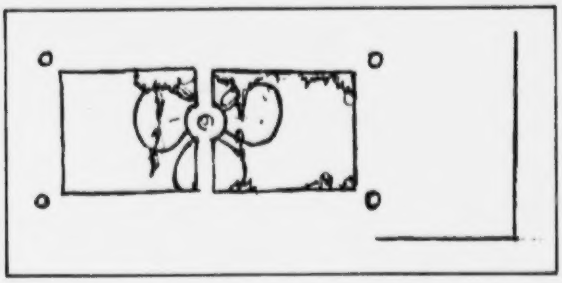


3. A problem could be frost buildup on the evaporator which may be an electrical problem, a stopped up drain, or the fan blade not turning. Remove the evaporator cover to determine if frost buildup is the problem.

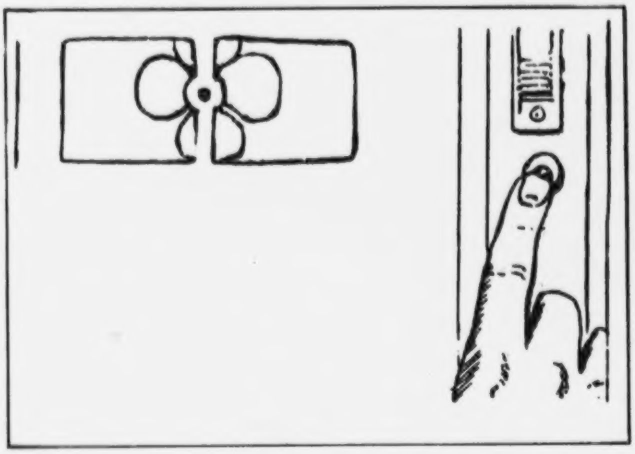
4. At the same time, determine if the drain is open by pouring a small amount of water in the drain trough.



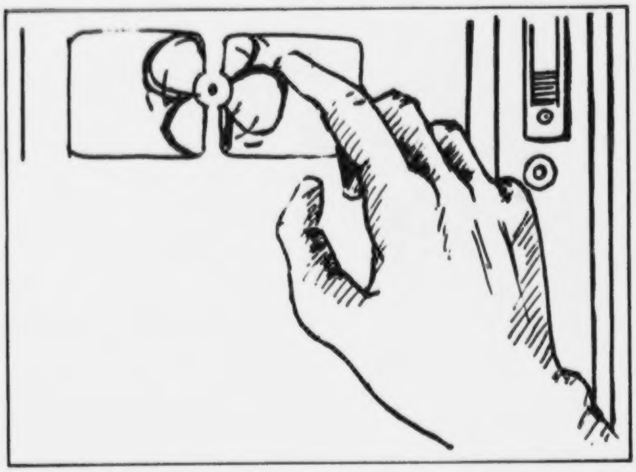
5. If the fan blades are restricted by frost, then the reason for frost building must be determined. With the exception of the drain (as mentioned before), the problem is usually electrical.



6. The fan may not be running due to bearings in the motor. With the motor exposed, and free of frost or ice, push the freezer fan door switch and observe. If the fan still does not run, try to turn the fan blades by hand. If the blades do not turn freely by hand, the motor bearings are too tight and the motor will have to be replaced. Lubrication of the bearings may help but usually will only last a short time.



7. If the blades turn freely but the motor will not run, the problem is electrical. (This is covered in another section.)



E. Troubleshooting an Inside Mechanical Problem: Refrigerant Overcharge

Now that you have studied some of the mechanical problems outside the sealed refrigeration system, you can concentrate on problems inside the refrigeration system. There are five: **1) overcharge, 2) undercharge, 3) inefficient compressor, 4) restriction, and 5) non-condensable gases.** You will use the three basic steps in troubleshooting: COMPLAINT, SYMPTOMS, and DIAGNOSIS.

Tools Needed:

Flashlight
Flat blade screwdriver
Nutdriver
Phillips screwdriver
Pliers
Clamp-around ammeter
Thermometer
Charging manifold
Line tap valve
Refrigerant

Customer Complaint:

The complaint will be different depending upon the amount of overcharge. Here are some common complaints.

1. The system runs all of the time, but does not cool enough.

2. The system runs a short time and shuts off; it is not cool enough.

3. It seems to be running too hard; sometimes the lights even dim when the system comes on and runs.

4. When it does shut off, it won't come on for a long time.

5. It tries to come on and run but can't.

REMEMBER: An overcharge is caused by improper servicing techniques. In other words, someone put too much refrigerant in the system!

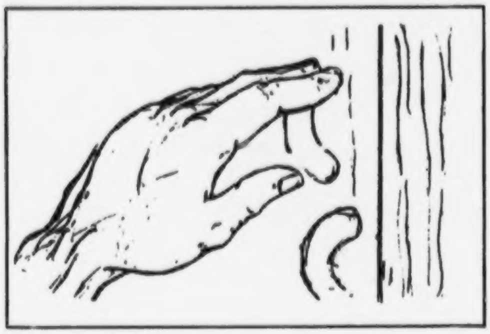
If the complaint is the same as one of those listed above, but the system has not been worked on, it is doubtful if the problem is an overcharge.

Symptoms:

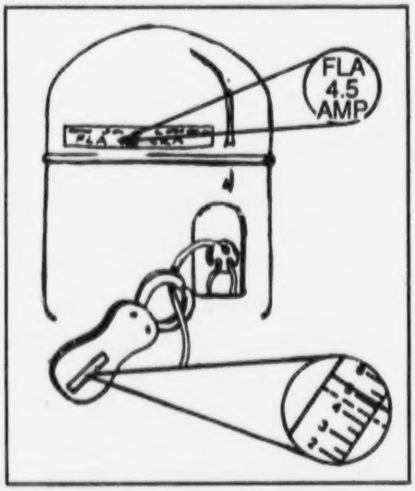
1. High head and suction pressure
2. High FLA amperage
3. Hot condenser
4. Overheating of compressor
5. Reduced cooling
6. Possible frosted suction line
7. Compressor shutting off on overload or high pressure switch

CAUTION: Remember that several problems may have some similar symptoms and some problems are outside of the system. Make certain that you explore these possibilities first. Then, when you are sure that the problem is inside the system, proceed with those checks.

Steps of Procedure:

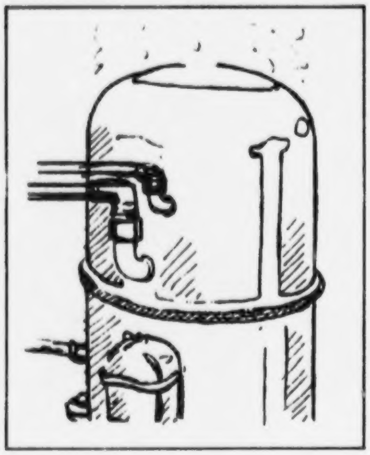


1. Check the feel of the outlet of the condenser coil. For normal operation, it should be just warm. With an overcharge, it will be HOT.

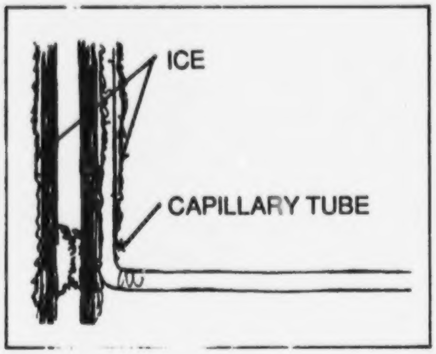


2. With the compressor running, check the amperage of the compressor and compare this reading with the rated FLA.

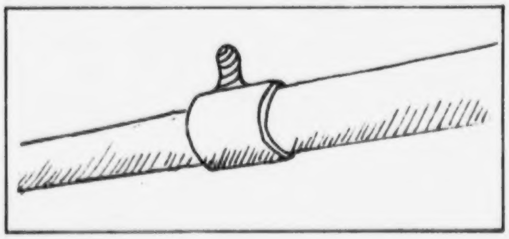
3. If the compressor is not running, it may be shut off on the overload. Check the feel of the compressor. If it seems too hot, turn the system off and allow the compressor to cool off for a few minutes before trying to restart.



4. Look at the suction line. Usually an overcharge will cause frost on the line when the system is running.



5. If no outside systems problem can be found, you must attach the charging manifold and check the operating pressures. If the system has been worked on before, a service valve should be on the tubing. If not, install a low side line tap valve on the process stub of the compressor. Install a high side line tap valve on a high side process stub (sometimes located at the outlet of the condenser).



6. Determine the normal operating suction and head pressures by the use of a temperature-pressure chart and compare these pressures to those of the system. An overcharge will give you high pressure readings.

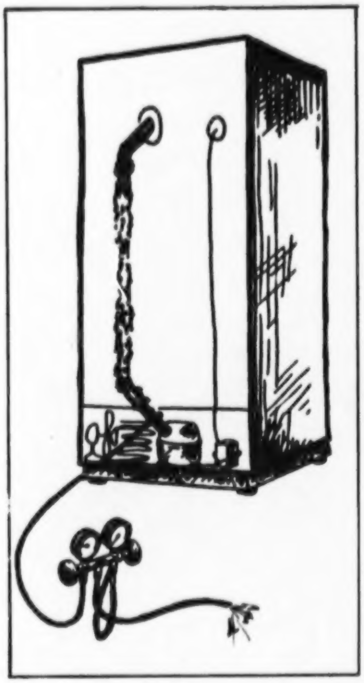
   If you compare your checks with the symptoms, you will make a DIAGNOSIS of an overcharged system.

TEMPERATURE PRESSURE CHART

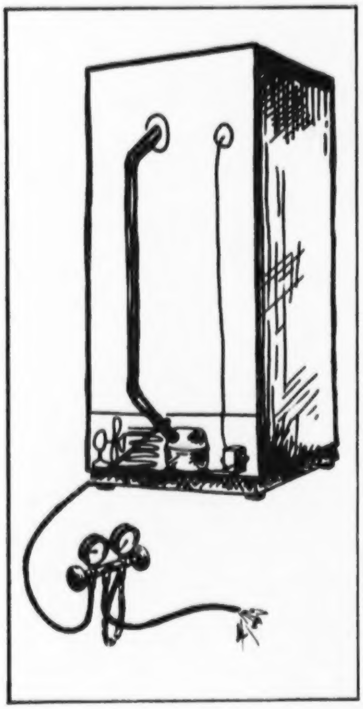
TEMPER-ATURE °F.	PRESSURE PSI REFRIGERANT					TEMPER-ATURE °F.	PRESSURE PSI REFRIGERANT					TEMPER-ATURE °F.	PRESSURE PSI REFRIGERANT				
	12	22	500	502	717		12	22	500	502	717		12	22	500	502	717
-60	19.0	12.0	...	7.0	18.6	12	15.8	34.7	21.2	43.2	25.6	42	38.8	71.4	48.4	83.4	61.6
-55	17.3	9.2	...	3.6	16.6	13	16.4	35.7	21.9	44.3	26.5	43	39.8	73.0	49.6	85.0	63.1
-50	15.4	6.2	...	0.0	14.3	14	17.1	36.7	22.6	45.4	27.5	44	40.7	74.5	50.7	86.6	64.7
-45	13.3	2.7	...	2.1	11.7	15	17.7	37.7	23.4	46.6	28.4	45	41.7	76.0	51.8	88.3	66.3
-40	11.0	0.5	7.9	4.3	8.7	16	18.4	38.7	24.2	47.7	29.4	46	42.6	77.6	53.0	90.0	67.9
-35	8.4	2.6	4.8	6.7	5.4	17	19.0	39.8	24.9	48.9	30.4	47	43.6	79.2	54.2	91.7	69.5
-30	5.5	4.9	1.4	9.4	1.6	18	19.7	40.8	25.7	50.1	31.4	48	44.6	80.8	55.4	93.4	71.1
-25	2.3	7.4	1.1	12.3	1.3	19	20.4	41.9	26.5	51.2	32.5	49	45.7	82.4	56.6	95.2	72.8
-20	0.6	10.1	3.1	15.5	3.6	20	21.0	43.0	27.3	52.4	33.5	50	46.7	84.0	57.8	96.9	74.5
-18	1.3	11.3	4.0	16.9	4.6	21	21.7	44.1	28.2	53.7	34.6	55	52.0	92.6	64.1	106.0	83.4
-16	2.0	12.5	4.9	18.3	5.6	22	22.4	45.3	29.0	54.9	35.7	60	57.7	101.6	71.0	115.6	92.9
-14	2.8	13.8	5.8	19.7	6.7	23	23.2	46.4	29.8	56.2	36.8	65	63.8	111.2	78.1	125.8	103.1
-12	3.6	15.1	6.8	21.2	7.9	24	23.9	47.6	30.7	57.4	37.9	70	70.2	121.4	85.8	136.6	114.1
-10	4.5	16.5	7.8	22.8	9.0	25	24.6	48.8	31.6	58.7	39.0	75	77.0	132.2	93.9	148.0	125.8
- 8	5.4	17.9	8.9	24.4	10.3	26	25.4	49.9	32.4	60.0	40.2	80	84.2	143.6	102.5	159.9	138.3
- 6	6.3	19.3	9.8	26.0	11.6	27	26.1	51.2	33.3	61.4	41.4	W.C. 85	91.8	155.7	111.5	172.5	151.7
- 4	7.2	20.8	11.0	27.7	12.9	28	26.9	52.4	34.3	62.7	42.6	90	99.8	168.4	121.2	185.8	165.9
- 2	8.2	22.4	12.1	29.4	14.3	29	27.7	53.6	35.2	64.1	43.8	95	108.2	181.8	131.3	199.8	181.1
0	9.2	24.0	13.3	31.2	15.7	30	28.4	54.9	36.1	65.4	45.0	100	117.2	195.9	141.9	214.4	197.2
1	9.7	24.8	13.9	32.2	16.5	31	29.2	56.2	37.0	66.8	46.3	A.C. 105	126.6	210.8	153.1	229.8	214.2
2	10.2	25.6	14.5	33.1	17.2	32	30.1	57.5	38.0	68.2	47.6	110	136.4	226.4	164.9	245.8	232.3
3	10.7	26.4	15.1	34.1	18.0	33	30.9	58.8	39.0	69.7	48.9	115	146.8	242.7	177.4	262.7	251.5
4	11.2	27.3	15.7	35.0	18.8	34	31.7	60.1	40.0	71.1	50.2	120	157.6	259.9	190.3	280.3	271.7
Ev 5	11.8	28.2	16.4	36.0	19.6	35	32.6	61.5	41.0	72.6	51.6	125	169.1	277.9	204.0	298.7	293.1
6	12.3	29.1	17.0	37.0	20.4	36	33.4	62.8	42.0	74.1	52.9	130	181.0	296.8	218.2	318.0	...
7	12.9	30.0	17.7	38.0	21.2	37	34.3	64.2	43.1	75.6	54.3	135	193.5	316.6	233.2	338.1	...
8	13.5	30.9	18.4	39.0	22.1	38	35.2	65.6	44.1	77.1	55.7	140	206.6	337.2	248.8	359.1	...
9	14.0	31.8	19.0	40.0	22.9	39	36.1	67.1	45.2	78.6	57.2	145	220.3	358.9	265.2	381.1	...
10	14.6	32.8	19.8	41.1	23.8	40	37.0	68.5	46.2	80.2	58.6	150	234.6	381.5	282.3	403.9	...
11	15.2	33.7	20.5	42.2	24.7	41	37.9	70.0	47.2	81.8	60.1	155	249.5	405.1	300.2	427.8	...

An overcharge can be repaired on a domestic refrigeration system by two methods:

1. Blow the entire refrigerant charge and recharge the system with the correct amount.



2. Slowly release a small amount of refrigerant through the charging manifold gauges. Watch the suction line frost and discharge refrigerant until the frost just disappears. After a few minutes, the frost may reappear, and the process will need to be repeated until no frost is on the suction line. This is a slow process and the service technician must watch the system all of the time.



F. Troubleshooting an Inside Mechanical Problem: Refrigerant Undercharge

Customer Complaint

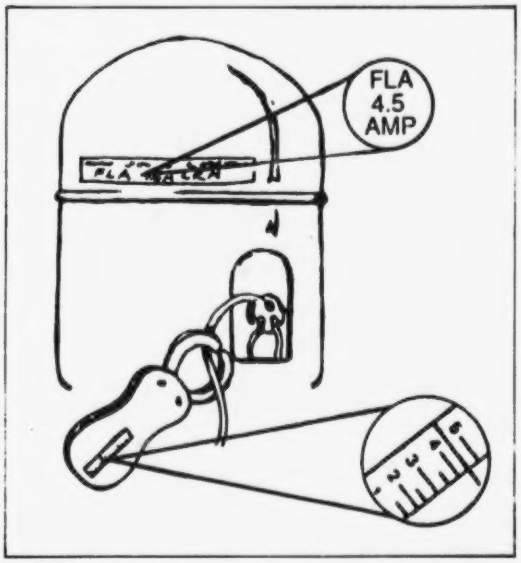
The system runs too much and doesn't cool enough. With a frostless refrigerator, a complaint may be that the vegetables freeze.

Symptoms:

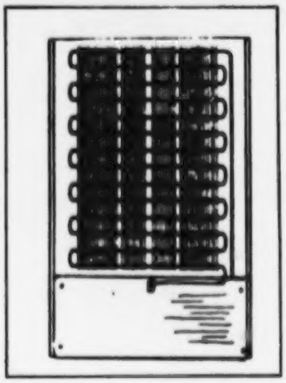
1. Low suction and head pressures
2. Low compressor amperage
3. Extended run time
4. Reduced cooling
5. Possible compressor cycling on low pressure control
6. Condenser too cool
7. Evaporator too warm
8. On some systems (especially central air conditioners), a frosted suction line.

Steps of Procedure:

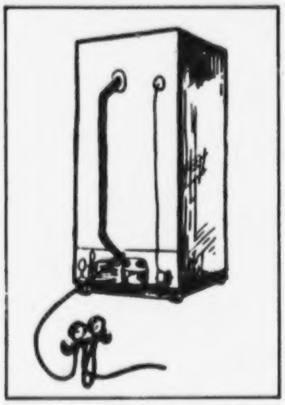
1. Check compressor running amperage and compare to FLA rating.



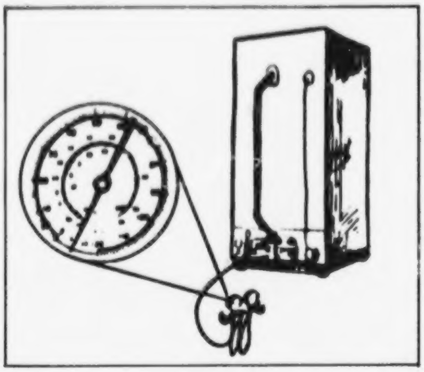
2. Feel the condenser from top to bottom (inlet to outlet). A normal system will be very warm at the inlet and reduce to barely warm at the outlet. An undercharged system will have a condenser that is too cool all of the way through.



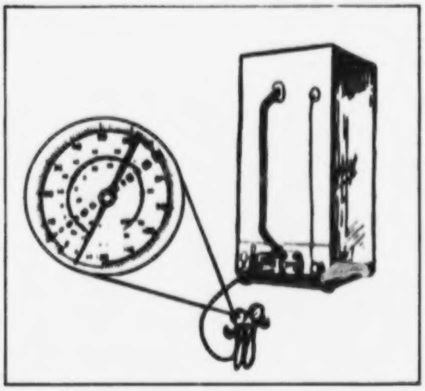
3. Look for suction line frosting. A central air conditioner may have frost on the evaporator and air flow will be restricted.

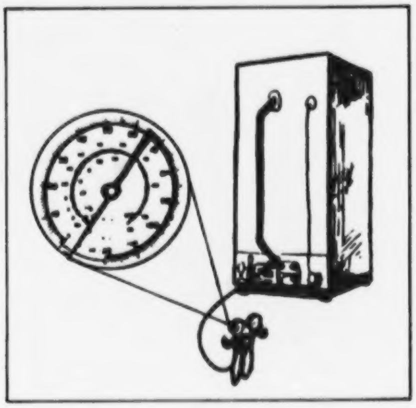


4. If no outside system problem can be found, you must attach the charging manifold and measure pressures at this time.

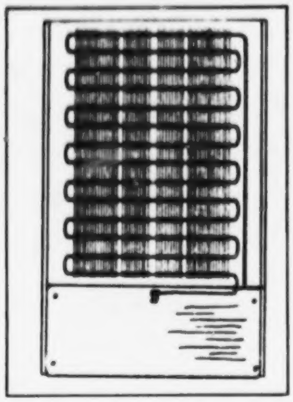


5. Determine the normal operating pressures by use of the temperature-pressure chart and compare with the actual operating system pressures. As stated before, an undercharge will have low pressures.





6. Many times a restriction will have symptoms similar to an undercharge. At this time, add a small amount of refrigerant and observe the system. IF THERE IS A RESTRICTION, the compound gauge needle will return to the original reading and remain there even though you added refrigerant.



7. If the condenser starts to get warm and the amperage increases, the system is refrigerating and the problem is an undercharge.

8. An undercharge is caused by either improper servicing techniques or a leak. To properly repair the system leak, detection must be done (this is covered in another section).

G. Troubleshooting an Inside Mechanical Problem: A System Restriction

System restriction is a term for a blockage inside the refrigerant lines. The restriction may be complete or partial. A partial restriction will allow some refrigerant to flow through. A complete restriction will not allow any to flow. Restrictions usually occur at the end of the capillary tube in the evaporator or in the filter dryer. Restrictions are caused by freezing of moisture in the system, wax buildup, oil sludge, carbon, and contaminants.

This section will only cover a complete restriction.

Customer Complaint:

1. The system runs but does not cool.
2. The system does not run very much at all and seems to be short cycling.

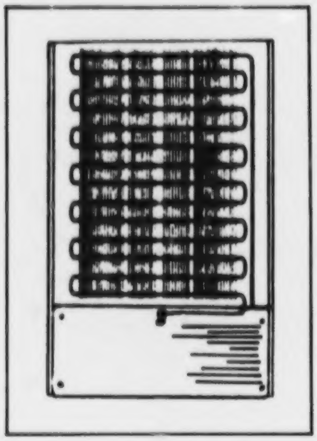
Symptoms:

1. The compressor may be cycling on a high pressure control
2. The condenser is too cool
3. The evaporator is too warm
4. Extended run time
5. Low running amperage (or high amperage on some systems)
6. Low head pressure (or high head pressure on some systems)
7. Low suction pressure, probably in a vacuum

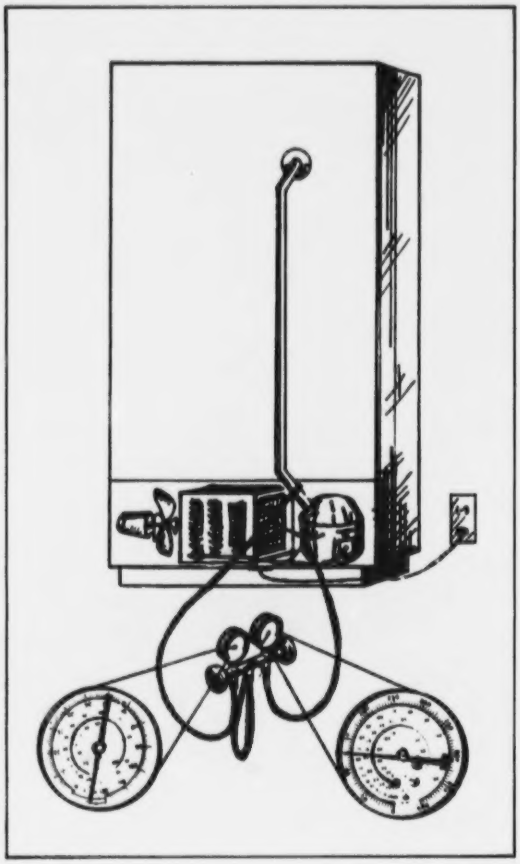
Steps of Procedure

1. Check compressor operating amperage and compare with FLA rating.

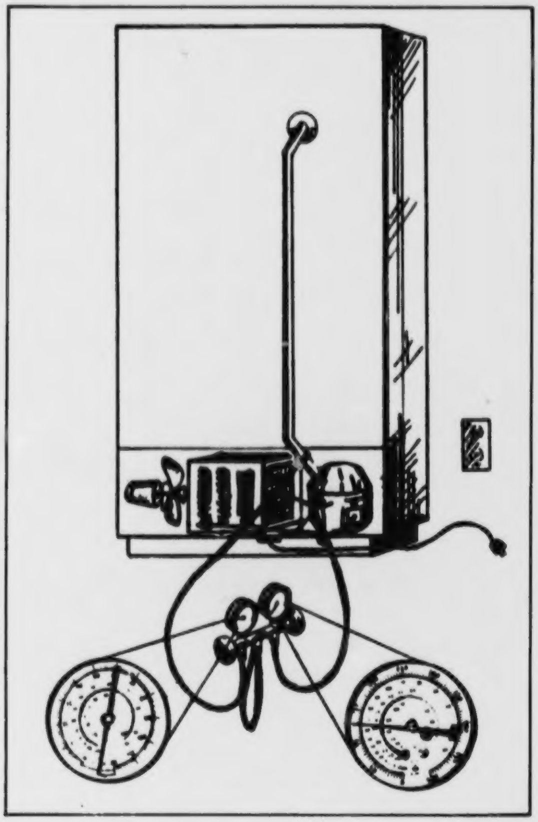
2. Look at the condenser and evaporator. Feel to determine if the evaporator is cool and the condenser is warm. This check will determine if any refrigeration is taking place.



If the compressor is running, very few outside system problems will keep the system from having some refrigeration. Therefore, it is necessary to enter the refrigeration system and make pressure checks.



3. Install the charging manifold and check suction and head pressures. Compare these with normal operating pressures on the temperature-pressure chart and also with the list of symptoms.

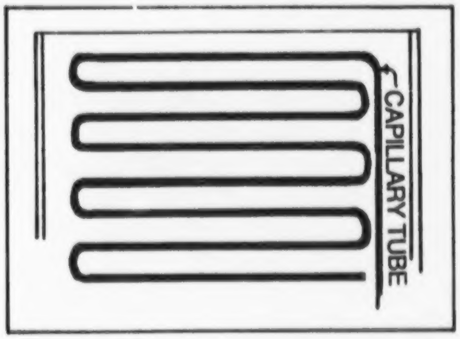


4. With a complete restriction, the pressures will not equalize on the off cycle. Turn the system off and watch the pressure gauges. The suction pressure should stay in a vacuum and you should notice little change in head pressure.

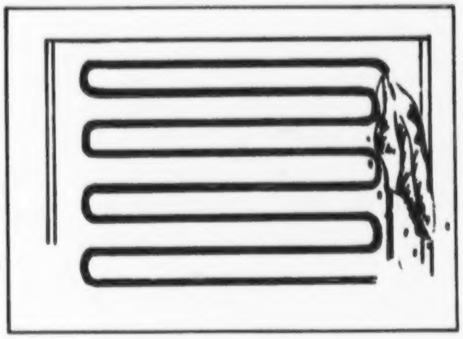
5. As stated before, the restriction and undercharge in a domestic system may have similar symptoms. If additional refrigerant is added to an undercharged system, it will start to refrigerate. However, if additional refrigerant is added to a system with a complete restriction, no refrigeration will occur. You may wish to try this.

6. To determine the type and location of restriction, follow this procedure.

If the restriction is caused by moisture, it will freeze up at the outlet of the capillary tube in the evaporator.



Turn off the system and remove the evaporator cover. Place a warm cloth on the end of the capillary tube. The heat from the warm cloth will cause the ice in the system to melt. You will hear the refrigerant flow through the system to equalize (a hissing sound). If this happens, moisture is in the system and a drying out procedure must be used.



H. Troubleshooting an Inside Mechanical Problem: Presence of Non-Condensable Gases

Non-condensable gases (air) enter the system by improper servicing techniques (failure to remove air when servicing) or through a refrigerant leak. The non-condensable gases collect in the condenser and will not pass on through the refrigeration system. This is a form of vapor lock.

Customer Complaint
The system just doesn't seem to cool enough.

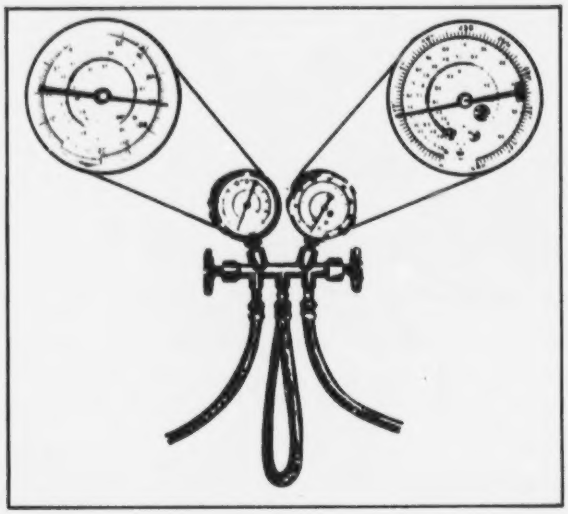
Symptoms:

1. Operating amperage slightly higher than normal
2. Suction and head pressures slightly higher than normal
3. Everything with the system seems to be slightly struggling.

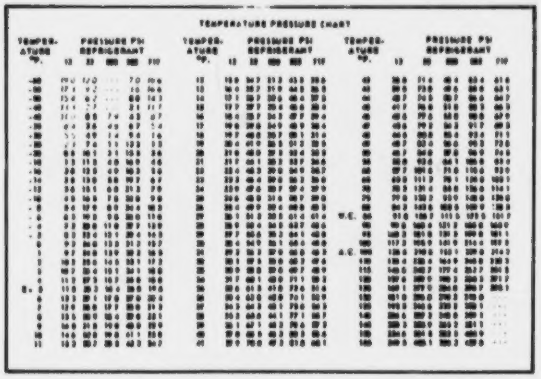
Many outside system problems can cause the same symptoms and you should make certain none of these problems are causing this complaint. When certain, proceed with the directions for diagnosing non-condensable gases.

Steps of Procedure

1. Install the charging manifold and observe the pressures with the system off and everything at room temperature.



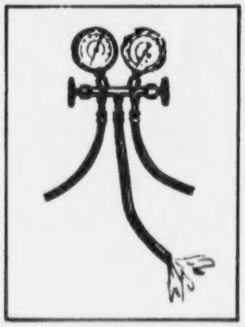
2. Determine the pressures for the type of refrigerant used in the system at the present room (ambient) temperature.



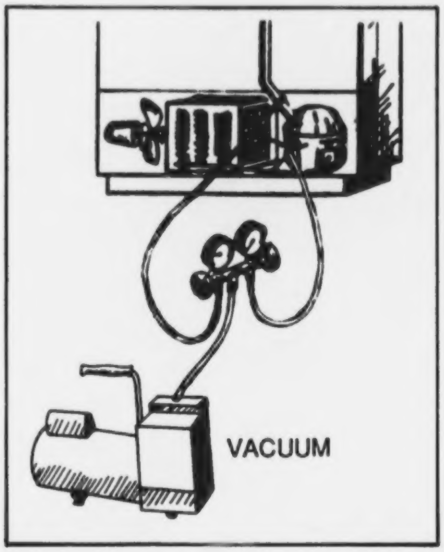
TEMPERATURE PRESSURE CHART

3. Non-condensable gases will cause the pressures to be slightly higher than those taken from the temperature-pressure chart.

4. On large systems, the non-condensables can be bled off from the condenser through the high side line and the service hose with the system running.



5. On small systems, it is recommended that the technician blow the refrigerant charge, purge, evacuate, and recharge.



DO SKILL SHEET 1

SKILL SHEET 1

Directions: Find the answers to the following questions in the chart below.

TEMPERATURE PRESSURE CHART

TEMPERATURE °F.	PRESSURE PSI REFRIGERANT					TEMPERATURE °F.	PRESSURE PSI REFRIGERANT					TEMPERATURE °F.	PRESSURE PSI REFRIGERANT				
	12	22	500	502	717		12	22	500	502	717		12	22	500	502	717
-60	19.0	12.0	...	7.0	18.6	12	15.8	34.7	21.2	43.2	25.6	42	38.8	71.4	48.4	83.4	61.6
-55	17.3	9.2	...	3.6	16.6	13	16.4	35.7	21.9	44.3	26.5	43	39.8	73.0	49.6	85.0	63.1
-50	15.4	6.2	...	0.0	14.3	14	17.1	36.7	22.6	45.4	27.5	44	40.7	74.5	50.7	86.6	64.7
-45	13.3	2.7	...	2.1	11.7	15	17.7	37.7	23.4	46.6	28.4	45	41.7	76.0	51.8	88.3	66.3
-40	11.0	0.5	7.9	4.3	8.7	16	18.4	38.7	24.2	47.7	29.4	46	42.6	77.6	53.0	90.0	67.9
-35	8.4	2.6	4.8	6.7	5.4	17	19.0	39.8	24.9	48.9	30.4	47	43.6	79.2	54.2	91.7	69.5
-30	5.5	4.9	1.4	9.4	1.6	18	19.7	40.8	25.7	50.1	31.4	48	44.6	80.8	55.4	93.4	71.1
-25	2.3	7.4	1.1	12.3	1.3	19	20.4	41.9	26.5	51.2	32.5	49	45.7	82.4	56.6	95.2	72.8
-20	0.6	10.1	3.1	15.5	3.6	20	21.0	43.0	27.3	52.4	33.5	50	46.7	84.0	57.8	96.9	74.5
-18	1.3	11.3	4.0	16.9	4.6	21	21.7	44.1	28.2	53.7	34.6	55	52.0	92.6	64.1	106.0	83.4
-16	2.0	12.5	4.9	18.3	5.6	22	22.4	45.3	29.0	54.9	35.7	60	57.7	101.6	71.0	115.6	92.9
-14	2.8	13.8	5.8	19.7	6.7	23	23.2	46.4	29.8	56.2	36.8	65	63.8	111.2	78.1	125.8	103.1
-12	3.6	15.1	6.8	21.2	7.9	24	23.9	47.6	30.7	57.4	37.9	70	70.2	121.4	85.8	136.6	114.1
-10	4.5	16.5	7.8	22.8	9.0	25	24.6	48.8	31.6	58.7	39.0	75	77.0	132.2	93.9	148.0	125.8
- 8	5.4	17.9	8.9	24.4	10.3	26	25.4	49.9	32.4	60.0	40.2	80	84.2	143.6	102.5	159.9	138.3
- 6	6.3	19.3	9.8	26.0	11.6	27	26.1	51.2	33.3	61.4	41.4	W.C. 85	91.8	155.7	111.5	172.5	151.7
- 4	7.2	20.8	11.0	27.7	12.9	28	26.9	52.4	34.3	62.7	42.6	90	99.8	168.4	121.2	185.8	165.9
- 2	8.2	22.4	12.1	29.4	14.3	29	27.7	53.6	35.2	64.1	43.8	95	108.2	181.8	131.3	199.8	181.1
0	9.2	24.0	13.3	31.2	15.7	30	28.4	54.9	36.1	65.4	45.0	100	117.2	195.9	141.9	214.4	197.2
1	9.7	24.8	13.9	32.2	16.5	31	29.2	56.2	37.0	66.8	46.3	A.C. 105	126.6	210.8	153.1	229.8	214.2
2	10.2	25.6	14.5	33.1	17.2	32	30.1	57.5	38.0	68.2	47.6	110	136.4	226.4	164.9	245.8	232.3
3	10.7	26.4	15.1	34.1	18.0	33	30.9	58.8	39.0	69.7	48.9	115	146.8	242.7	177.4	262.7	251.5
4	11.2	27.3	15.7	35.0	18.8	34	31.7	60.1	40.0	71.1	50.2	120	157.6	259.9	190.3	280.3	271.7
Ev 5	11.8	28.2	16.4	36.0	19.6	35	32.6	61.5	41.0	72.6	51.6	125	169.1	277.9	204.0	298.7	293.1
6	12.3	29.1	17.0	37.0	20.4	36	33.4	62.8	42.0	74.1	52.9	130	181.0	296.8	218.2	318.0	...
7	12.9	30.0	17.7	38.0	21.2	37	34.3	64.2	43.1	75.6	54.3	135	193.5	316.6	233.2	338.1	...
8	13.5	30.9	18.4	39.0	22.1	38	35.2	65.6	44.1	77.1	55.7	140	206.6	337.2	248.8	359.1	...
9	14.0	31.8	19.0	40.0	22.9	39	36.1	67.1	45.2	78.6	57.2	145	220.3	358.9	265.2	381.1	...
10	14.6	32.8	19.8	41.1	23.8	40	37.0	68.5	46.2	80.2	58.6	150	234.6	381.5	282.3	403.9	...
11	15.2	33.7	20.5	42.2	24.7	41	37.9	70.0	47.2	81.8	60.1	155	249.5	405.1	300.2	427.8	...

What is the normal operating suction and head pressure:

1. of 22 PSI refrigerant at 13° F (room temperature)?

2. of 717 PSI refrigerant at 60° F (room temperature)?

3. of 500 PSI refrigerant at 10° F (room temperature)?

4. of 502 PSI refrigerant at 0° F (room temperature)?

5. of 12 PSI refrigerant at 17° F (room temperature)?

TROUBLESHOOTING MECHANICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

UNIT REVIEW

Directions: Choose the best answer to the questions below.

1. Mechanical troubleshooting behind the compressor is divided into three parts: (1)outside, (2)inside and (3)underneath.
   TRUE FALSE

2. A dirty condenser will cause above normal head or discharge pressure.
   TRUE FALSE

3. Excessive amperage readings could be caused by a
   a. dirty condenser.
   b. broken fan motor.
   c. bent fan blades.
   d. all of the above

4. The system has a frosted suction line, and you are looking for an outside problem. This condition could be caused by a
   a. dirty filter.
   b. broken fan belt on the blower.
   c. dirty and clogged evaporator.
   d. all of the above

5. Symptoms of a refrigerant overcharge might include
   a. the system runs for a long time, but does not shut off.
   b. the system runs a short time and shuts off without cooling.
   c. the system tries to run but can't.
   d. all of the above

6. An overcharge of refrigerant could cause extremely high compressor amperage.

TRUE FALSE

7. One symptom of a restriction is

a. low head pressure. b. frosted suction line.
c. inoperative fan motor. d. cool evaporator.

8. When servicing air conditioning and refrigeration internal problems, the student must always wear

a. a three-piece suit. b. safety glasses.
c. SCUBA gear. d. steel-toed workboots.

9. When servicing a small refrigeration system, you repair a leak and install a new filter dryer. The system should now be drained of refrigerant, purged, evacuated and charged.

TRUE FALSE

TROUBLESHOOTING MECHANICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. List five symptoms for each of the five possible problems inside the refrigeration system: overcharged, undercharged, inefficient compressor, restriction, and non-condensable gases.			
2. Identify tools used to gather information and determine symptoms.			
3. Name all of the possible mechanical problems outside of the sealed refrigeration system.			
4. Use a process of elimination to determine the system problem.			

Satisfactory - Should Move On ☐

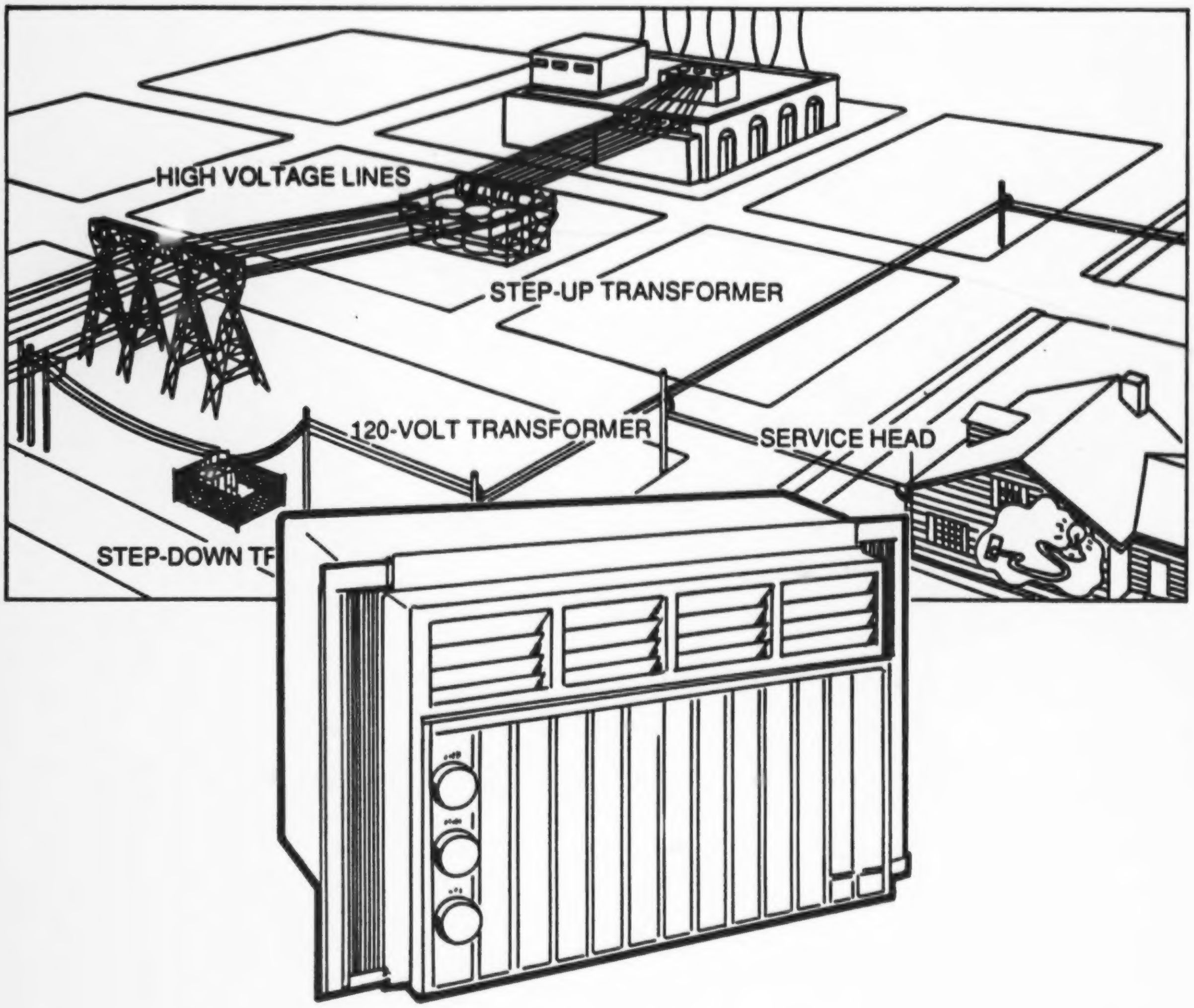
Repeat This Unit ☐

__________________________ Student's Signature/Date

__________________________ Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 8

Troubleshooting Electrical Problems

in Domestic Refrigeration Systems

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

TROUBLESHOOTING ELECTRICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

INTRODUCTION

Approximately 75% of the problems in domestic refrigeration systems are electrical in nature. This means that the ability to troubleshoot electrical problems is a very important part of a service technician's duties. This unit will concentrate on electrical components found in domestic (household) systems and the methods of troubleshooting each part or component.

UNIT OBJECTIVES

After completing this unit, you should be able to troubleshoot electrical problems in a domestic refrigeration system.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Apply the principles of electrical troubleshooting to diagnose and repair domestic systems.
2. Use **SAFE TECHNIQUES** when working in hazardous situations.
3. Analyze system operation from electrical diagrams.
4. Use electrical test equipment to diagnose.

Check the Statement that Fits You Best

☐ I can do these tasks and want to go through the Performance Checklist.

SEE YOUR INSTRUCTOR

☐ I want to study the information in this unit before I do the Performance Checklist.

TURN PAGE AND BEGIN

A. Terms and Equipment

Terms

1. Automatic - something moving or working by itself.

2. Data - information, especially information that is used to make a decision.

3. Diagnosis - a decision that is made about a problem after looking at all the information on the situation and deciding what caused it.

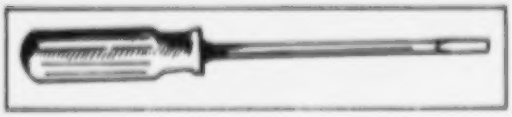
4. Manual - something made or done by hand.

5. Potential - the amount of electrical force in a circuit (measured in volts).

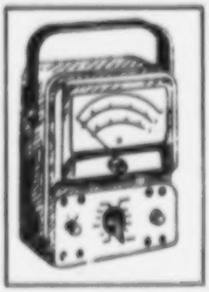
6. Symptoms - signs that show something is not working normally.

7. Troubleshooting - finding and repairing the causes of problems in mechanical equipment.

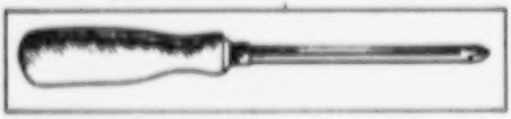
Equipment



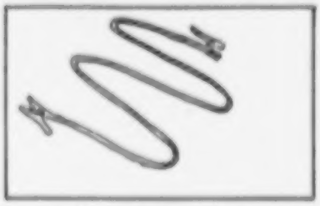
Flat screwdriver



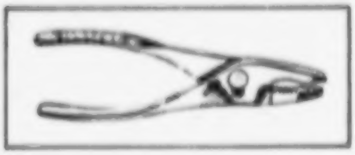
Multimeter



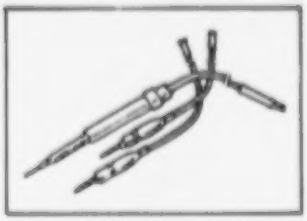
Phillips screwdriver



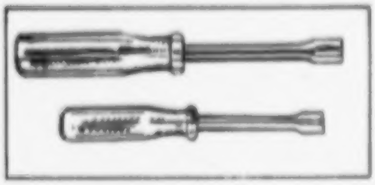
Jumper wire



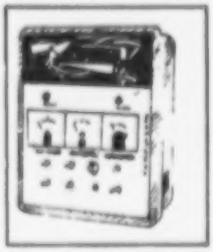
Common pliers



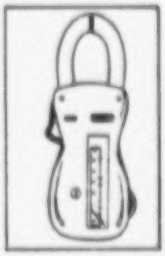
Test cord



Nutdriver set



Hermetic analyzer



Clamp-around ammeter

B. Fundamentals of Electrical Troubleshooting

**ELECTRICITY IS DANGEROUS - ELECTRICAL SHOCK CAN KILL!
ABSOLUTELY NO HORSEPLAY IS ALLOWED IN THE SHOP!**

DO NOT ATTEMPT ANY TESTS UNTIL YOUR INSTRUCTOR HAS EXAMINED YOUR PROJECT AND GIVEN APPROVAL TO GO AHEAD!

ALWAYS DISCONNECT ELECTRICAL POWER AT THE FUSED DISCONNECT YOURSELF BEFORE MOVING ANY WIRES OR MAKING RESISTANCE CHECKS

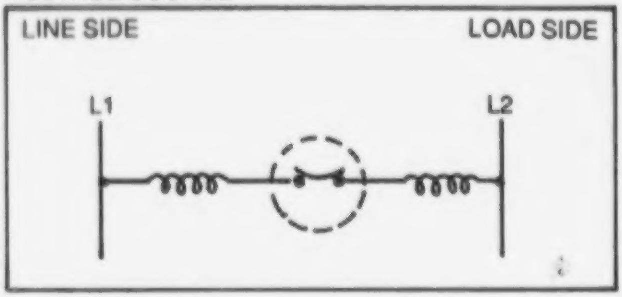
SOME CHECKS MUST BE MADE WITH THE POWER ON, THIS MEANS YOU MUST TAKE EXTRA CAUTION TO PREVENT INJURY TO YOURSELF AND OTHERS OR DAMAGE TO EQUIPMENT.

You should understand the following statements about electrical troubleshooting before you start work on any system.

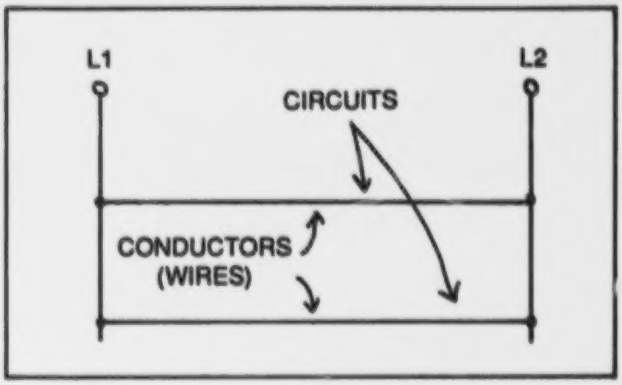
Before current will flow, the following are necessary:

1. Voltage Source. A power supply is needed to force current to move along a conductor. This source may be a transformer, generator, or the electrical wires coming to a house from the power lines outside. Sometimes this is referred to as L1 and L2 on a wiring diagram. L1 is located on the left (also called the line side) and L2 is located on the right (also called the load side) of a diagram.

VOLTAGE SOURCE



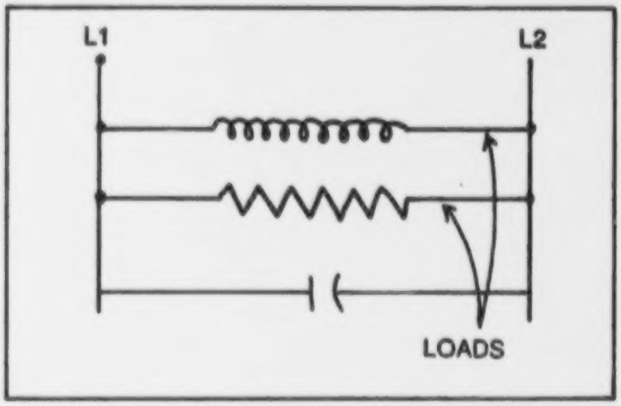
2. **Current Path.** Conductors are used to transfer the current from the source to a load. These **conductors** are known as wires and form a network that may be very confusing. A network of wires is also called a **circuit.** It is simple, though, if you only look at one circuit at a time. You may also want to remember the term **load.** There is only one load in each circuit. One current path is shown outlined.



3. **Load.** Each circuit must have a load.

   A load is anything that changes electrical energy to some other type of energy, such as magnetic, sound, light, heat. A motor is an example of a load.

   A motor contains coils of wire called windings. The windings have magnetic energy when electrical current flows through them. This magnetic energy causes the motor to run. You could think of a load as something that does work or causes something to happen. Normally there is only one load per circuit. Motors and loads are outlined.



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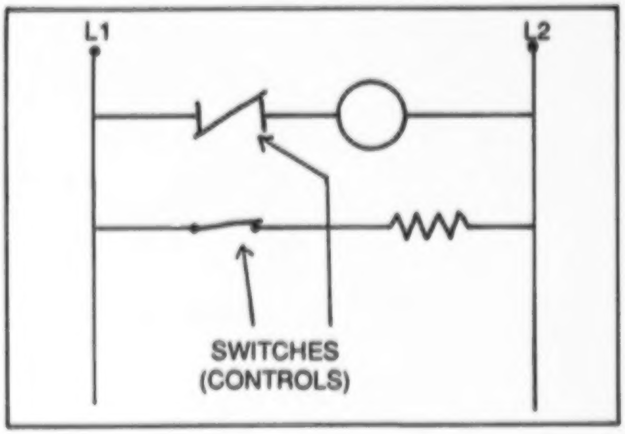
4. A control. Most circuits contain controls also known as **switches** that allow the load to operate when we want it to by opening or closing the circuit or path.



SWITCHES are devices that are used to complete a path or circuit for electron flow. Switches have many different sizes, shapes, and descriptions. A circuit may have as many switches as needed to properly control the load.

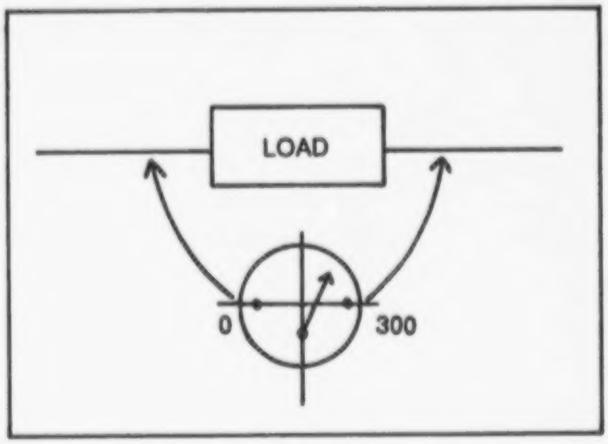
An example of a switch is the button that is pushed in when the door on a refrigerator is closed. That button/switch opens and closes the switch to the cabinet light. This allows the light to come on when the refrigerator door is opened.

C. Steps of Procedure for Electrical Troubleshooting

1. Determine if voltage or potential is available to the circuit.

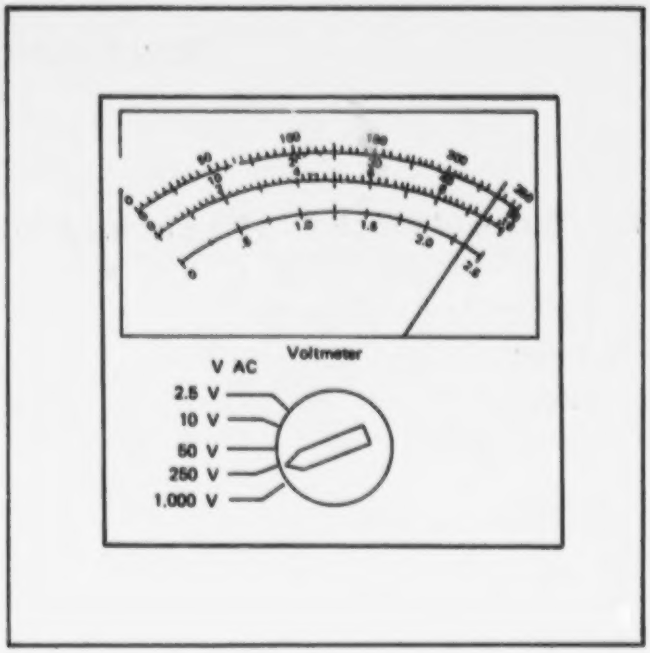
2. Check for potential at the load that should be working but isn't. If potential is available at the load, it should work. If potential isn't available, the problem is in the load.

   Only two things can happen electrically to a device: an open or a short. The load must be checked for these problems. If potential is not at the load, proceed to step number 3.



3. If potential is available to the circuit but not at the load, you will find the problem at the point in the circuit that you also find voltage.

4. Use a volt meter to check the switches in the load circuit in question.


Voltmeter
V AC
2.5 V
10 V
50 V
250 V
1,000 V

DO ACTIVITY SHEET 1

EXERCISES IN CIRCUITS CONTAINING LOADS AND SWITCHES

ACTIVITY SHEET

It is important to learn how to troubleshoot electrical circuits in your head and on paper with the use of schematics or diagrams. This exercise will show you how to think through the situation instead of just guessing. In this activity you will try to do the following:

- Explain the relationship of loads and switches in a circuit by using technical terms.
- Establish a logical troubleshooting process.
- Determine if the requirements for current flow are met in various situations on a system diagram.

Do not worry about shortcuts or the amount of time you take to solve a problem now. Short cuts will come naturally after you completely understand electrical troubleshooting. If you follow the steps listed below, electrical problem solving will become relatively simple.

Directions:

1. Review the electrical diagram part of this activity sheet.
2. Most of the loads, switches, and junctions have letters.
3. Answer the attached questions concerning the diagram by referring to the assigned letters.

D. Steps of Procedure for Electrical Component Testing

Before you troubleshoot with live equipment, it is important that you understand schematics or diagrams. Practice "troubleshooting" electrical circuits in your head and on paper, using schematics. Try to develop your problem-solving skills so that you can think through a situation instead of just guessing.

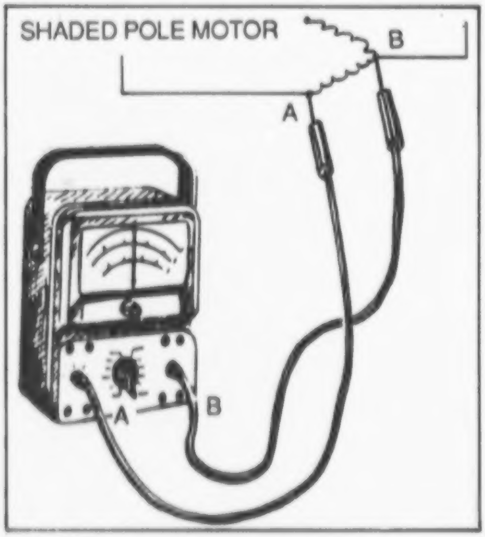
Remember what you have learned about loads and switches. When you become confident thinking a problem through and troubleshooting diagrams, you will be able to switch to live equipment.

These steps of procedure will combine troubleshooting with diagrams and live equipment. In this section you will learn to:

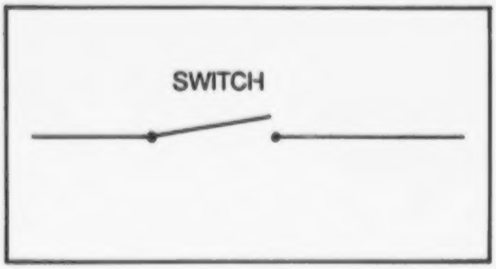
- Relate electrical components on diagrams to live equipment.
- Identify load circuits and switches that control loads.
- Demonstrate voltage testing of components.
- Use diagrams to determine components in a system.
- Apply electrical troubleshooting techniques.

Work with your instructor on checking voltages at loads and switches. Ask the instructor to show you the following.

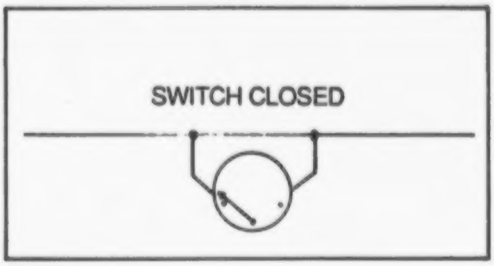
1. A voltmeter checks potential difference across a load. Therefore, the leads of the meter should be attached as in the diagram. The load changes electrical energy (voltage) to another form of energy such as magnetic. Therefore, when checking across a load, a potential difference will exist, and the voltmeter will indicate voltage.



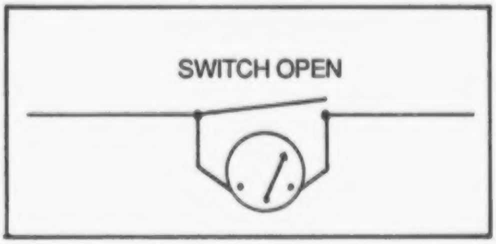
2. Checking voltage across the terminals of a switch is a little different. You must understand what the meter is telling you. A switch is not a load and does not change electrical energy to anything else. It simply provides a path for current flow. It does not have a potential difference as a load, and the voltmeter only checks potential difference.



   If a switch is closed (as in the diagram) and the leads of the voltmeter are attached to the terminals, the meter will not read voltage even if voltage is available to the switch. This is because there is not a potential difference! An indication of 0 volts actually means the switch is closed.

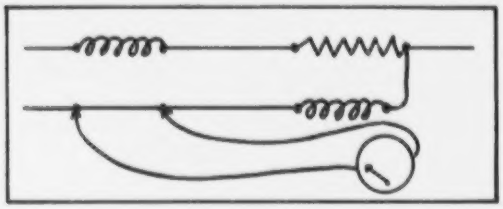


   An open switch makes the path to the load incomplete or open and current cannot flow. This condition does offer a potential difference across the terminals of the switch and the voltmeter will indicate voltage. This means the switch is open and possibly bad.

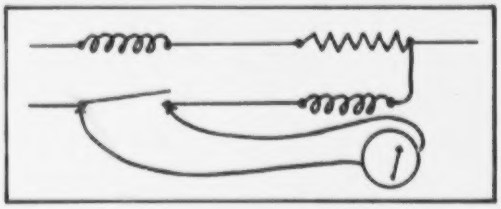


3. REMEMBER

   An indication of **0 volts** across the terminals of a switch means the switch is **CLOSED**.

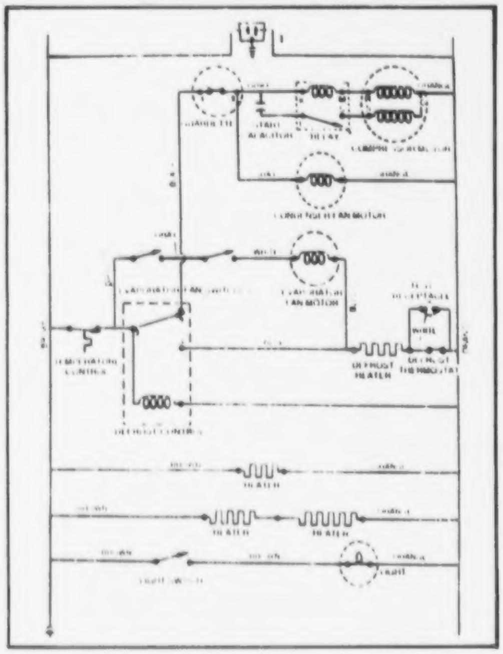


   An indication of **voltage** across the terminals of a switch means the switch is **OPEN**.



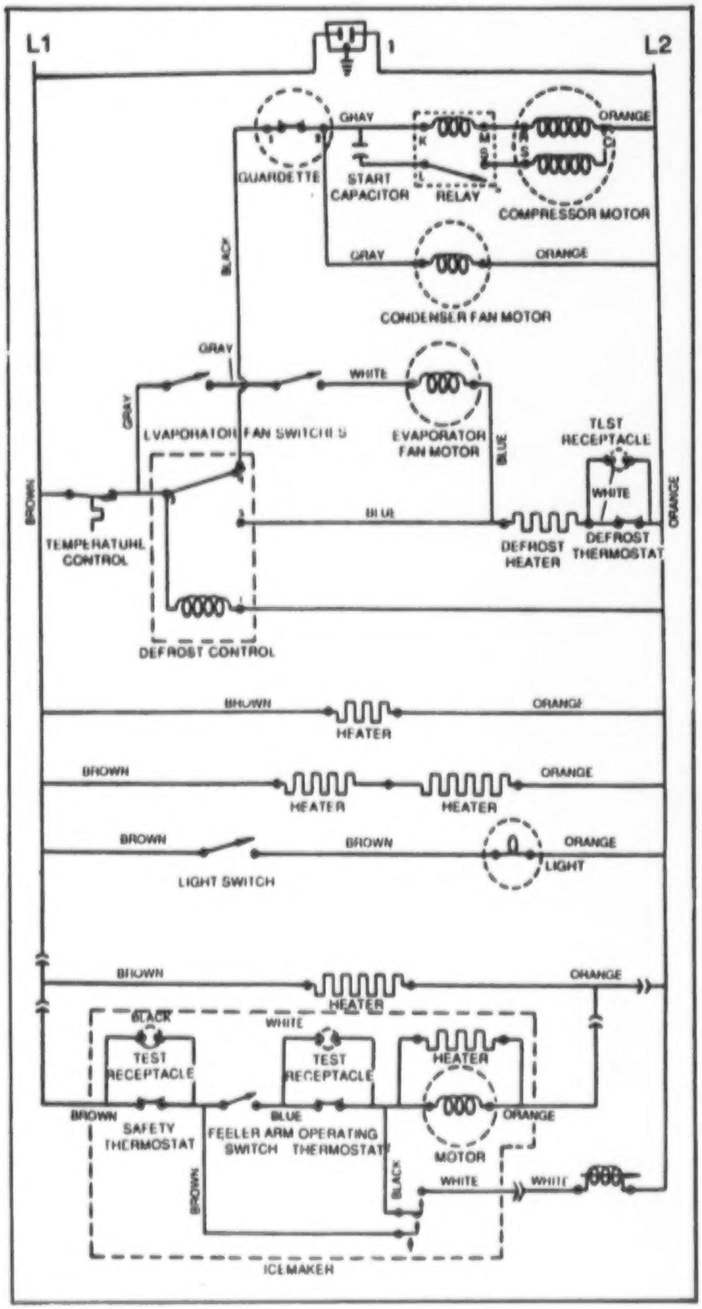
4. This is an electrical diagram for a very typical refrigerator-freezer combination with electric defrost.

   (NOTE: Your instructor may have a refrigerator that uses a diagram similar to this one and also a bad compressor that you can use for practice.)



5. We know the compressor must operate to produce cooling. Find the compressor on the diagram. If you cannot find it, ask your instructor for help.

6. Look at just the circuit that contains the compressor, all the way from L1 to L2. Now list the loads in the circuit other than the compressor and list the switches that are also in the circuit that could keep the compressor from operating.


L1
1
L2
GUARDETTE
GRAY
START CAPACITOR
K
L
RELAY
M
S
ORANGE
C
COMPRESSOR MOTOR
BLACK
GRAY
ORANGE
CONDENSER FAN MOTOR
GRAY
GRAY
WHITE
EVAPORATOR FAN SWITCHES
EVAPORATOR FAN MOTOR
BLUE
TEST RECEPTACLE
WHITE
ORANGE
BROWN
TEMPERATURE CONTROL
BLUE
DEFROST HEATER
DEFROST THERMOSTAT
DEFROST CONTROL
BROWN
HEATER
ORANGE
BROWN
HEATER
HEATER
ORANGE
BROWN
LIGHT SWITCH
BROWN
LIGHT
ORANGE
BROWN
HEATER
ORANGE
BLACK
TEST RECEPTACLE
WHITE
TEST RECEPTACLE
HEATER
BROWN
SAFETY THERMOSTAT
FEELER ARM SWITCH
BLUE
OPERATING THERMOSTAT
MOTOR
ORANGE
BROWN
BLACK
WHITE
WHITE
ICEMAKER

7. If you understand what you have just done, you have competed a very important part of electrical troubleshooting. You have eliminated all circuits except what you want to check, and determined the switches that control the load.

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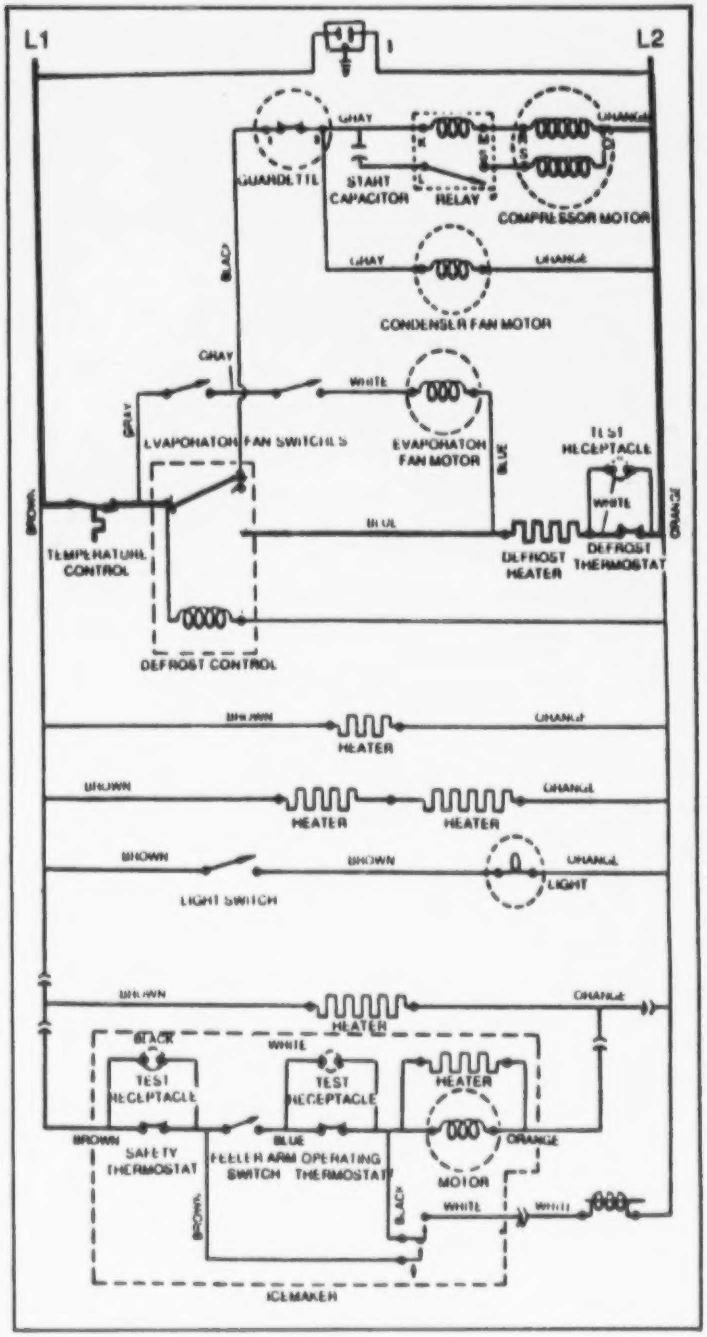
8. You should have determined that only four switches control the operation of the compressor: 1) the relay contacts, 2) overload, 3) timer contacts, 4) thermostat. Look at these again on the diagram.

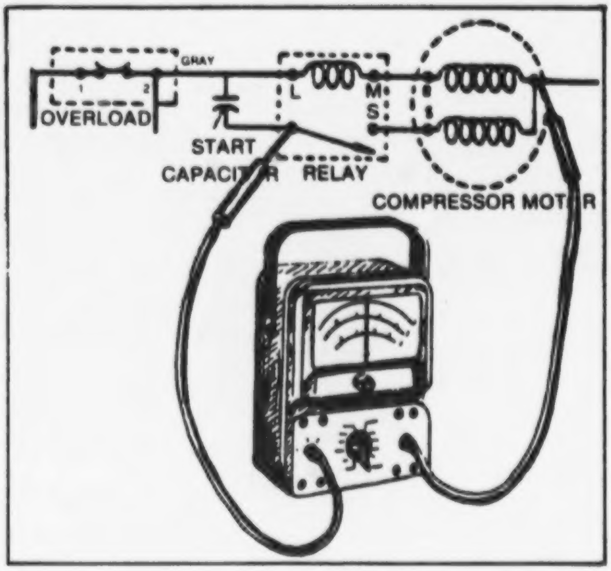

L1
1
L2
GRAY
ORANGE
GUARDETTE
START CAPACITOR
RELAY
COMPRESSOR MOTOR
BLACK
GRAY
ORANGE
CONDENSER FAN MOTOR
GRAY
WHITE
GRAY
EVAPORATOR FAN SWITCHES
EVAPORATOR FAN MOTOR
BLUE
TEST RECEPTACLE
WHITE
BROWN
TEMPERATURE CONTROL
BLUE
DEFROST HEATER
DEFROST THERMOSTAT
ORANGE
DEFROST CONTROL
BROWN
HEATER
ORANGE
BROWN
HEATER
HEATER
ORANGE
BROWN
BROWN
LIGHT SWITCH
ORANGE
LIGHT
BROWN
HEATER
ORANGE
BLACK
WHITE
TEST RECEPTACLE
TEST RECEPTACLE
HEATER
BROWN
SAFETY THERMOSTAT
FEELER ARM SWITCH
BLUE
OPERATING THERMOSTAT
ORANGE
MOTOR
BROWN
BLACK
WHITE
WHITE
ICEMAKER

If the compressor is not operating, the problem is the compressor motor that is inside the compressor housing or one of the switches in the compressor circuit. You can determine which it is by a testing procedure known as process of elimination. Notice this is a testing procedure, not changing of parts until you hit the right one!

9. By process of elimination, you will check the switches in the circuit. First, go to the load that should be working but isn't, and check for voltage. This load is the compressor. If it isn't getting voltage, it can't work.

10. The question now is: Where is voltage being lost? In other words, which switch is open?

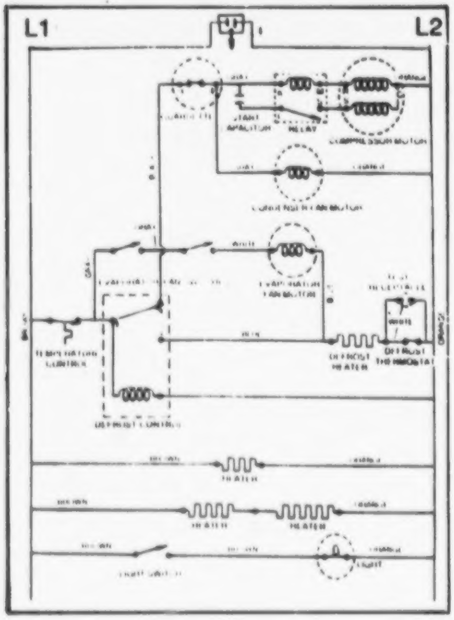
11. To find the voltage (or which switch is open), leave one lead of the voltmeter at the compressor terminals, as in the picture. Place the other lead at the line side of the first switch on the line side of the compressor.



NOTE: The compressor must be trying to start from this switch to be closed.

12. If the meter indicates voltage, then you have found the open circuit--that switch.

If you still do not have voltage, repeat this same step with each switch on the line side of the compressor until voltage is indicated. Ask your instructor for help if you do not understand this process.



13. These steps in troubleshooting only indicate which load or switch is open or shorted. They do not tell how or why.

E. Symptoms and Components: Frosted Evaporator

You have now learned the basic steps in electrical troubleshooting. You traced the load circuits and examined the loads and switches. However, you did not determine the symptoms of the system. This section covers symptoms that cause the service technician to look at a certain load circuit.

In this section you will learn how to:

- Use system symptoms to eliminate electrical circuits.
- Analyze symptoms to determine which circuits should be tested.
- Check electrical components in a refrigerator that could cause a frosted evaporator.

A technician must learn to use the customer complaint, visual inspection, and symptoms to determine the possible components (load or switches) that can cause a particular problem. In putting these factors together to diagnose a problem, the service technician must answer some questions. This may seem as if there are a lot of questions to answer, and you may be wondering why you can't just jump in and find the problem? Many people try this and they are the ones that don't get called back by the customer, because they spend too much time and usually don't solve the problem.

The questions that need to be answered are:

1. What should the system be doing? If the control is turned off or the electrical cord is unplugged, the system will not operate.

2. What is the system doing? If the compressor is trying to start but pulls high amperage and kicks off the overload, there is no need to check for voltage at the power cord.

Ask your instructor to explain these two questions and how some components can be eliminated by thinking, before any checks with testers are made.

We will establish symptoms and use those to determine which loads could cause a specific problem, then check the load circuits, and loads to identify the problem.

Troubleshooting is a logical process of separating good from bad or bad from good. To make this separation, you must have a knowledge of the symptoms, make checks, and then decide what is wrong based upon the data. For example, if you had trouble seeing clearly in your left eye, had an ingrown toenail, and also a crack in the left lens of your glasses, it is relatively simple to make a diagnosis.

Let's look at the process that took place in this example. As simple as the decision was, you still used the same steps to draw a conclusion. The **symptom** was not seeing clearly. The probable causes were two, either an ingrown toenail or a cracked lens. Rapidly you analyzed this data and determined that an ingrown toenail would not have an effect on seeing clearly. Thus, you separated the information until only one thing remained that could cause the problem. This example is simplified; but the thought process that occurred is important. You use the same process in troubleshooting.

STEPS OF PROCEDURE

NOTE: Ask your instructor to set up the following problems in a refrigerator. Use the steps of procedure to solve the problems as listed below.

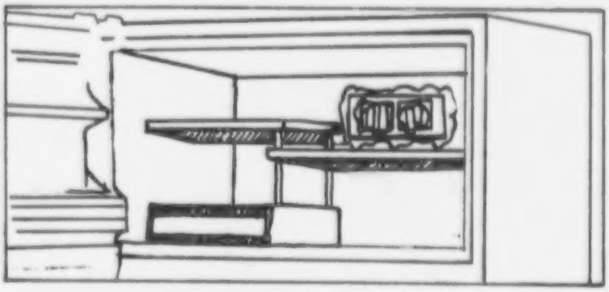
Tools Needed

Flat screwdriver
Phillips screwdriver
Common pliers
Nutdriver set
Multimeter
Clamp-around ammeter

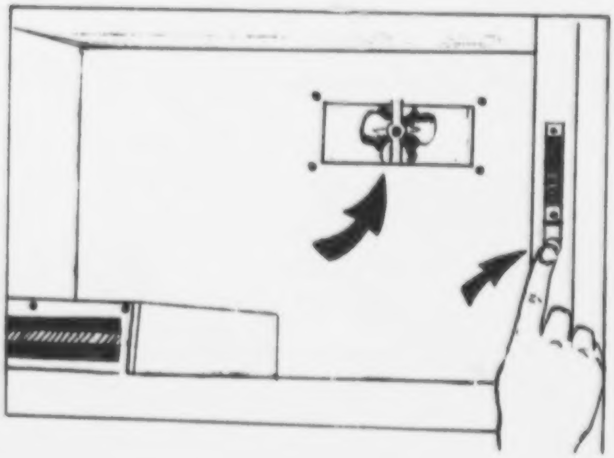
Symptoms

The freezer and refrigerator sections are not cold enough. The refrigerator runs too much. You notice a small amount of ice or frost on the panel that covers the evaporator.

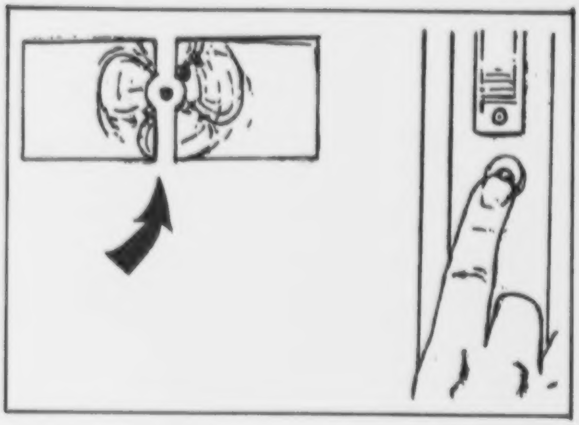
1. Ice and frost should not be on the panel. The defrost system should keep the ice and frost from accumulating on the evaporator coil. Usually two things will cause a frosted evaporator: a failure in the defrost system or insufficient air flow.



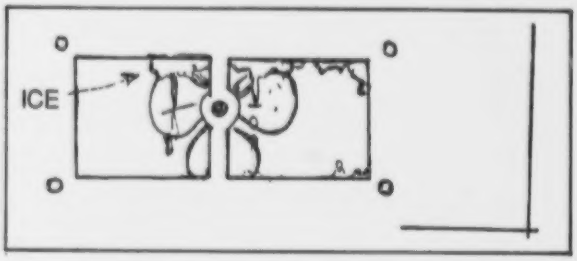
2. Insufficient air flow is probably the easiest and quickest to check. Air circulates through the evaporator by a small fan located very close to the evaporator. Check the fan by pushing in on the fan door switch and watch the fan for rotation. You may need to remove a fan diffuser to see the fan blades.



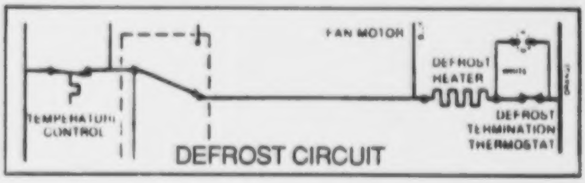
3. If the blades turn, the switch, fan motor, and circuit must be good. If the blades do not turn, you must troubleshoot the fan motor circuit, using the process of elimination (described earlier).

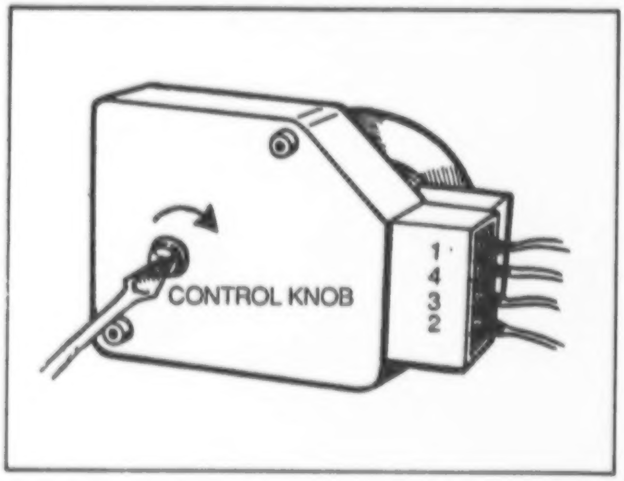


4. Occasionally, the blades may be held in place by frost or ice caused by another problem.

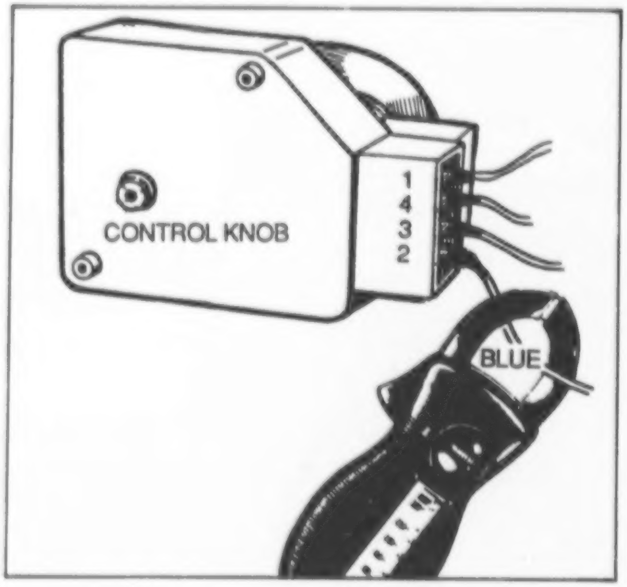


5. If air flow is not the problem, the second possibility is the defrost system. Examination of the defrost circuit reveals one load (defrost heater), defrost termination switch (DFT) and contacts inside the timer assembly.

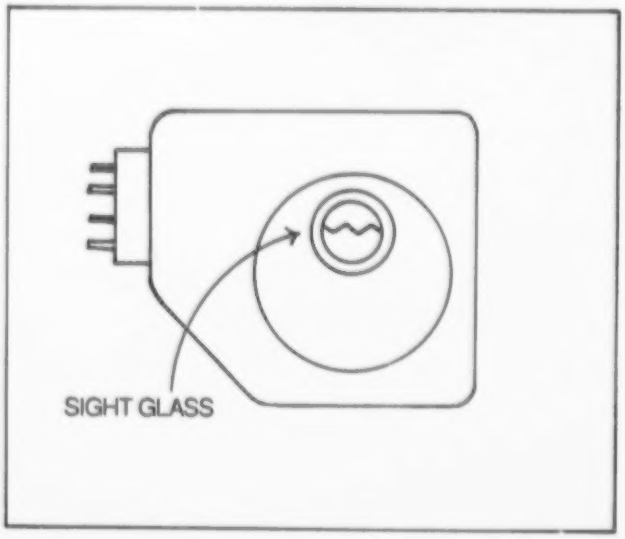

FAN MOTOR
DEFROST HEATER
TEMPERATURE CONTROL
DEFROST CIRCUIT
DEFROST TERMINATION THERMOSTAT



6. An easy check to make is to turn the timer manually by using a flat blade screwdriver to turn a knob sticking out of the timer housing. Turn the knob slowly, with the refrigerator operating, until you hear a "click" and the refrigerator shuts off. The system should be in defrost and the heater should operate to melt the frost from the evaporator. **ALWAYS TURN THE CONTROL KNOB ON THE TIMER CLOCKWISE.**

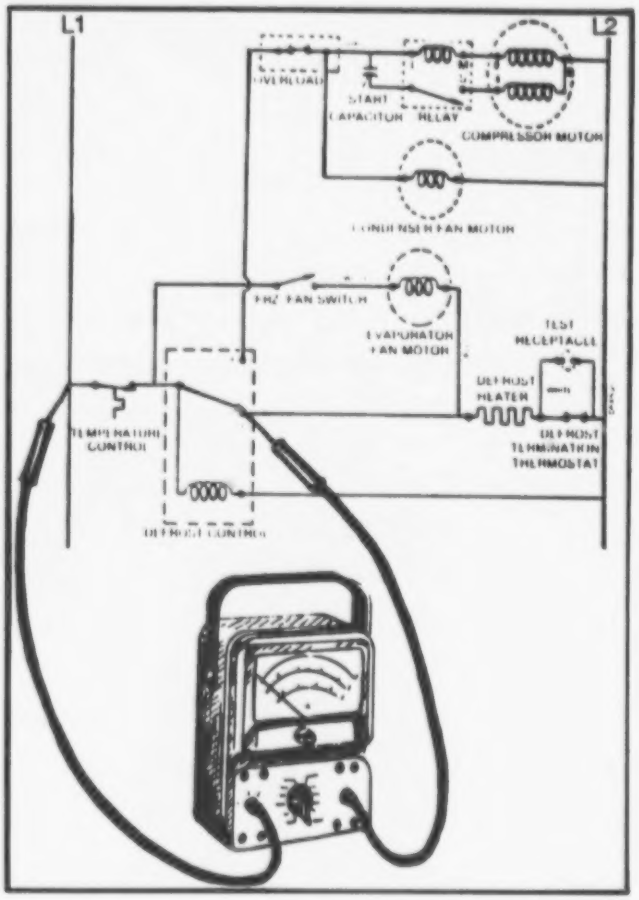


7. Attach a clamp-around ammeter around the wire going from the timer assembly, defrost contacts, to the defrost heater circuit. An amperage reading indicates the defrost circuit will operate if the timer is turned manually.

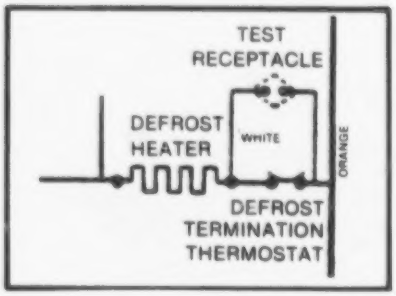


8. The small timer motor is responsible for turning the gears inside the timer assembly. Many times the timer motor has a small sight glass so the flywheel can be seen turning. Either the motor is open or shorted, or the gears are stuck. In either case, the timer assembly must be replaced.

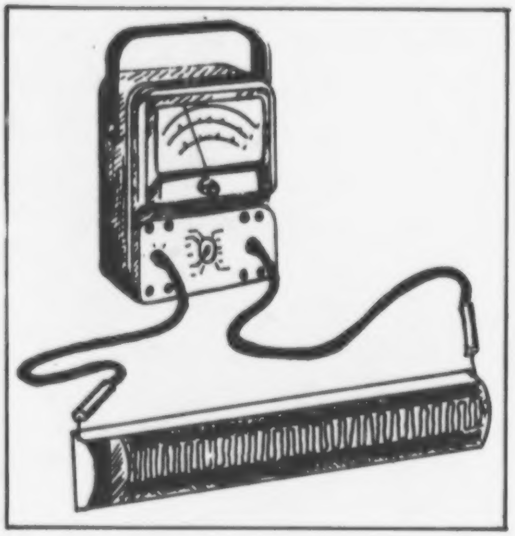
9. If the defrost circuit does not indicate amperage (in step 7), one of the three components in the circuit is bad. Because the timer is available for testing, use a multimeter to check for voltage at the timer terminal going to the defrost circuit. With the timer still in manual defrost, a voltage reading with the meter leads placed on the L1 terminal and defrost circuit terminal indicates an open switch. 0 voltage with the leads in the same position indicates a closed switch in voltage is available at the timer. Remember the results when checking loads and switches


L1
L2
OVERLOAD
START
CAPACITOR
RELAY
COMPRESSOR MOTOR
CONDENSER FAN MOTOR
FRZ FAN SWITCH
EVAPORATOR
FAN MOTOR
TEST
RECEPTACLE
DEFROST
HEATER
DEFROST
TERMINATION
THERMOSTAT
TEMPERATURE
CONTROL
DEFROST CONTROL

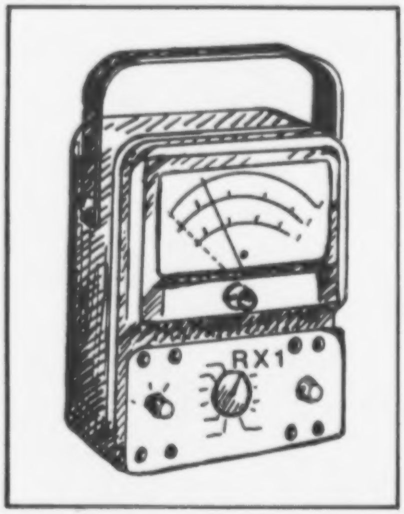
10. If the switch is open, the timer assembly must be replaced. However, if the switch is closed, there are two possible problems: DTT or the heater. The DTT can be difficult, so check the heater next. Remove the panel that covers the evaporator to gain access to the heater, since it is mounted either on the coil or very close.


TEST
RECEPTACLE
DEFROST
HEATER
WHITE
ORANGE
DEFROST
TERMINATION
THERMOSTAT

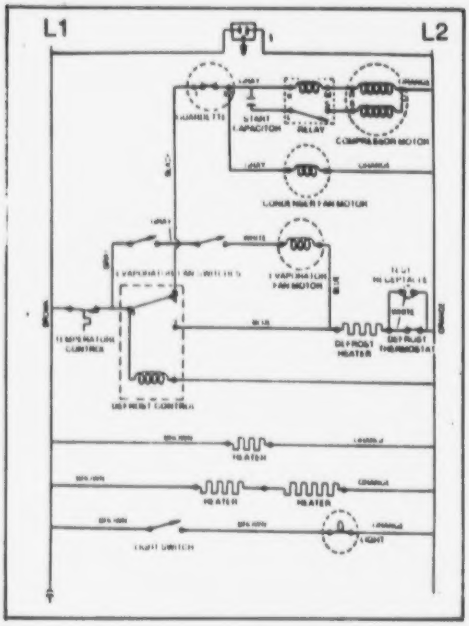
11. Attach the multimeter leads on each end of the heater and check for voltage. This is a load, because it changes electrical energy to heat energy. If voltage is indicated with the check, the heater should work. A resistance check of the heater will indicate an open heater. DON'T MAKE A RESISTANCE CHECK NOW. GO ON TO STEP 12.



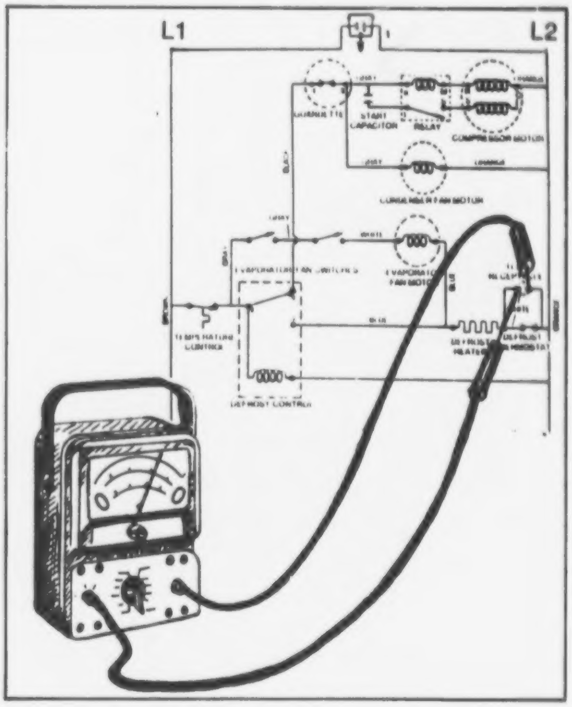
12. Disconnect the refrigerator from the electrical power. Leave both leads of the multimeter attached to each end of the heater. Turn the multimeter to RX1 resistance scale. If the heater is open, the meter needle will not move. A good heater will cause the needle to move, indicating a circuit through the heater exists.



13. An open heater check will require heater replacement. If the heater is good, only one component is left, the DTT. The DTT is a bimetal switch sensitive to changes in temperature. It automatically opens when the frost is melted off of the coil and closes at approximately 15 degrees Fahrenheit in the freezer.


L1
L2
START CAPACITOR
RELAY
COMPRESSOR MOTOR
CONDENSER FAN MOTOR
EVAPORATOR FAN MOTOR
TEMPERATURE CONTROL
DEFROST HEATER
DEFROST THERMOSTAT
DEFROST CONTROL
HEATER
HEATER
HEATER
LIGHT SWITCH
LIGHT

14. The DTT can be checked for resistance with the multimeter (as in step 12) when checking the heater. If the DTT checks open, make certain it is at the temperature that it should be closed, before replacement.


L1
L2
START CAPACITOR
RELAY
CONDENSER FAN MOTOR
TEMPERATURE CONTROL
DEFROST CONTROL

F. SYMPTOMS AND COMPONENTS: THE COMPRESSOR CIRCUIT

(NOTE: The procedure for checking compressors was presented in a previous unit and will not be repeated here.)

It is important to know what symptoms result because of a component failure in the compressor circuit, and how to check the entire circuit. Many times the compressor is blamed when actually it is not the problem. Instead of just saying "the compressor is bad," the technician should develop the habit of stating **how** the compressor is bad. If a technician cannot state what is actually wrong with a compressor, other components should be checked very carefully.

In this section you will learn how to:

- Explain the operation of components in the compressor circuit.
- Determine possible component problems by the symptoms.
- Diagnose compressor circuit component problems.

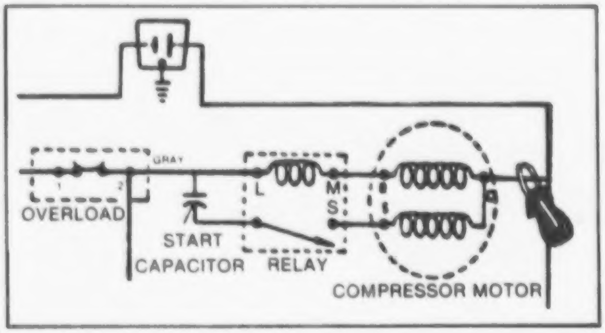
Tools and Materials

Flat blade screwdriver
Common pliers
Multimeter
Test cord
Hermetic analyzer

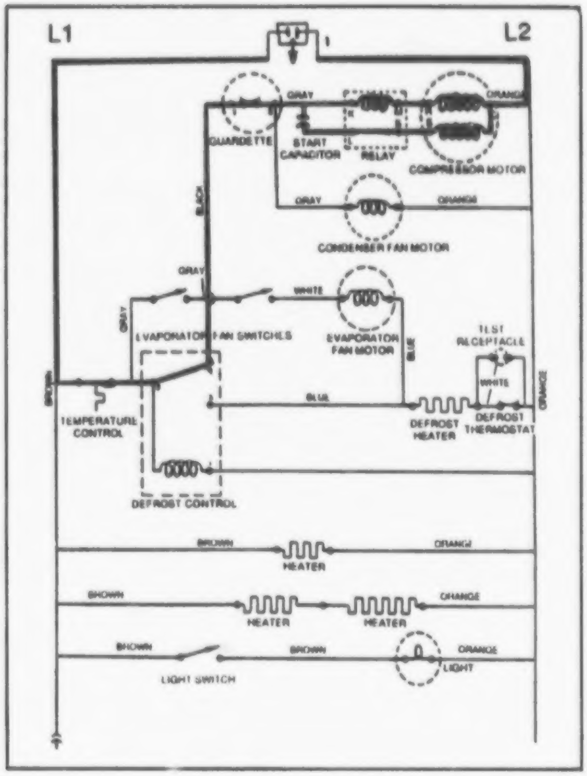
Phillips screwdriver
Nutdriver set
Clamp-around ammeter
Jumper wire
A refrigerator

Steps of Procedure

1. Review and study the compressor circuit, completing a path from L1 all the way through L2 of the diagram.



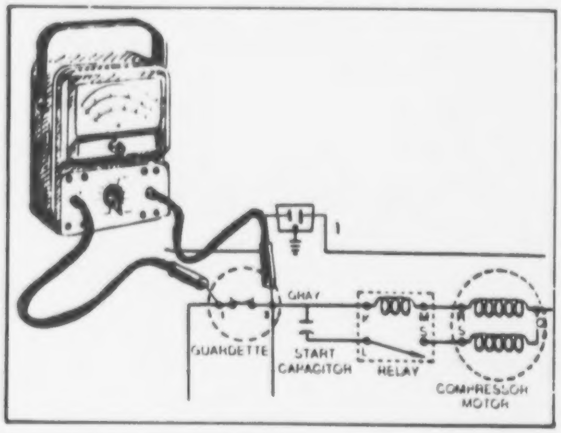
2. You should conclude that the compressor circuit consists of the following switches: overload, relay contacts, defrost timer assembly contacts, and temperature control. Make certain you can locate all of these before you continue. This circuit is outlined for your review.


L1
L2
1
GRAY
ORANGE
GUARDETTE
START CAPACITOR
RELAY
COMPRESSOR MOTOR
BLACK
GRAY
ORANGE
CONDENSER FAN MOTOR
GRAY
WHITE
GRAY
EVAPORATOR FAN SWITCHES
EVAPORATOR FAN MOTOR
BLUE
TEST RECEPTACLE
WHITE
BROWN
ORANGE
TEMPERATURE CONTROL
BLUE
DEFROST HEATER
DEFROST THERMOSTAT
DEFROST CONTROL
BROWN
ORANGE
HEATER
BROWN
ORANGE
HEATER
HEATER
BROWN
BROWN
ORANGE
LIGHT SWITCH
LIGHT

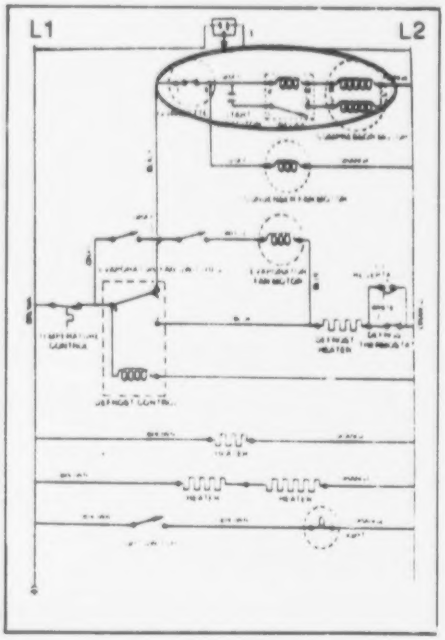
3. We will discuss the following symptoms: a) the compressor does nothing, it won't even try to start; b) the compressor tries to start but doesn't, it hums then kicks off on the overload; c) the compressor runs for a short time, then shuts off on the overload. Ask your instructor to explain these symptoms.

Symptom: The Compressor Does Nothing--It Doesn't Even Try to Start

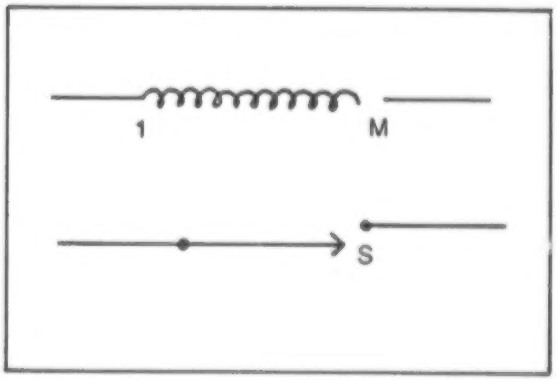
4. Let's examine the first symptom, the compressor does nothing, it doesn't even try to start. Before making any checks, **THINK!** Also review the compressor circuit of the diagram. Remember that an electrical device is either good, open or shorted.



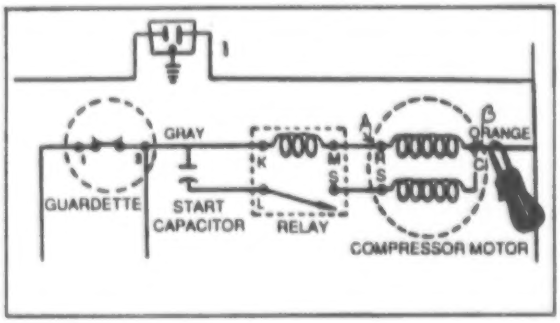
5. Start the process of elimination. If everything is set so the compressor **should** be operating but **isn't**, can the compressor be the problem? This is possible; however, it probably is not shorted or it would try to start. If the compressor is the problem, it must have an **open** circuit. Also, if you examine the diagram, you will notice that the compressor relay is a current relay.



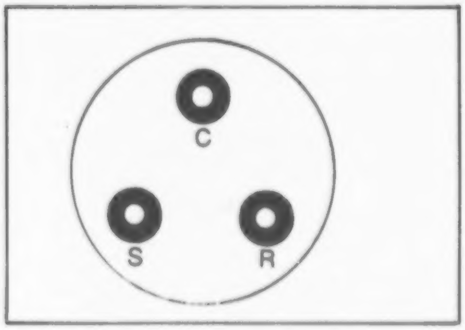
6. A current relay has normally open contacts. The contacts are in series with the start winding, thus if the compressor is doing nothing, and the problem is in the compressor, it must be either an open run winding or common. Ask your instructor to explain.



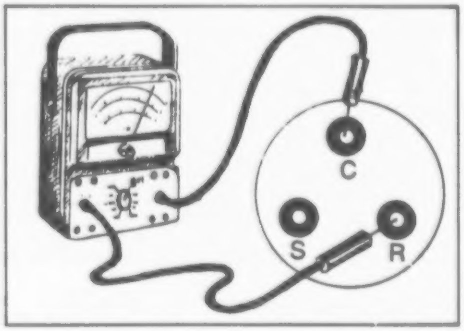
7. In electrical troubleshooting, go to the load that should be working but isn't. Check for potential at that load. Since the compressor can be the problem, use the multimeter. Set it on a scale to read 120 volts and check for voltage at points A and B as indicated on the diagram. If you have voltage, the compressor should operate unless there is a compressor problem. You should then disconnect the electrical power, set the multimeter on RX1 resistance scale, and check for an open start winding or common as illustrated in step eight.



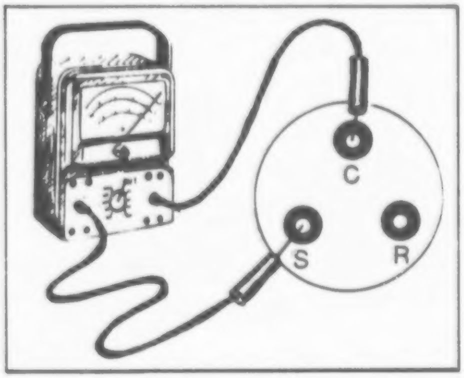
8. To make a resistance check, remove all wires from the compressor. Be sure to make a diagram, label the wires, or locate them on an existing diagram. Determine which are the common, start, and run terminals of the compressor.



9. Attach the meter leads to the common and run terminals. If the meter needle moves, a circuit is indicated and an open start winding is not the problem.*



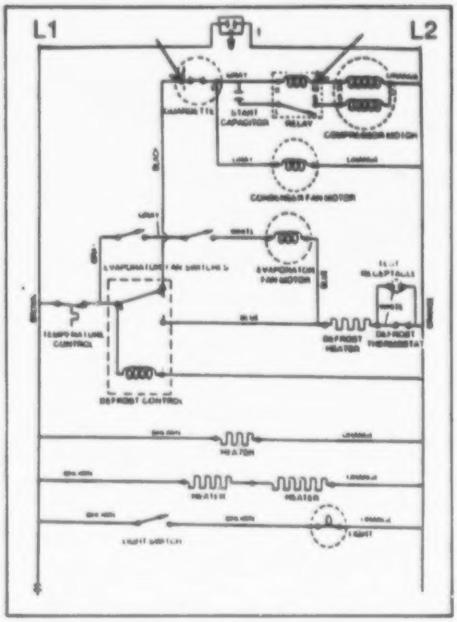
10. Attach the meter leads to the common and start terminals. If the meter needle moves, a circuit is indicated and an open start winding is not the problem.*



* With symptom 1 and voltage to the compressor, the problem **should** be either of those described in steps 9 and 10. The instructor may wish to have the student check a refrigerator that has one of these problems.

11. In step 7, if no voltage was indicated at the compressor, an open circuit must be someplace else.

12. Now use the process of elimination by leaving the meter lead attached to point A and moving the other lead to the line side of the overload. Did you find voltage? If so, this indicates an open overload. Ask your instructor to explain this check and also why the overload is open. Is the overload the problem? Could the problem be something else? What?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EVAPORATOR FAN MOTOR
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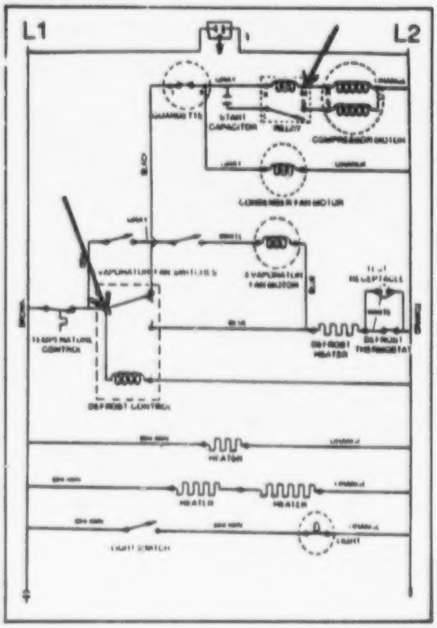
DEFROST CONTROL
DEFROST HEATER
DEFROST THERMOSTAT
HEATER
HEATER
HEATER
LIGHT SWITCH
LIGHT

13. If no voltage was indicated at the line side of the overload, move the meter lead to the line side of the defrost timer contact in the compressor circuit. You will need to check the diagram to determine this contact. Is voltage at this point? If yes, the contact is open and should be closed unless the timer is in the defrost mode. You may wish to disconnect the power, attached wires, and make a resistance check across the contacts.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TEST RECEPTACLE
TEMPERATURE CONTROL
DEFROST CONTROL
DEFROST HEATER
DEFROST THERMOSTAT
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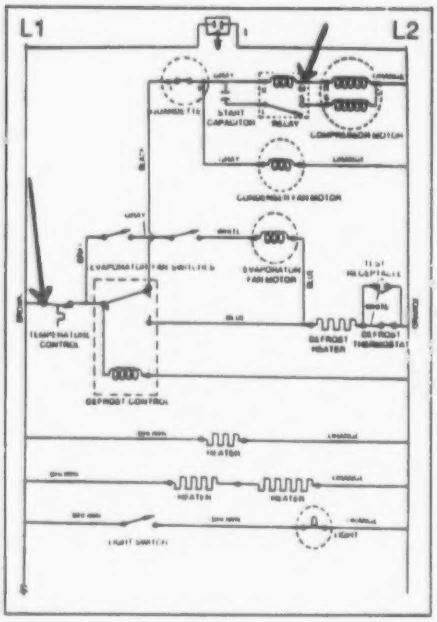
HEATER
HEATER
LIGHT SWITCH
LIGHT

14. If no voltage was indicated at the line side of the defrost timer contacts, only one switch is left, the temperature control. As in the previous steps, leave one meter lead in the same position but move the other to the line side of the temperature control. Also as in the other checks, if voltage is indicated, the switch is open.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TEMPERATURE CONTROL
DEFROST CONTROL
DEFROST HEATER
DEFROST THERMOSTAT
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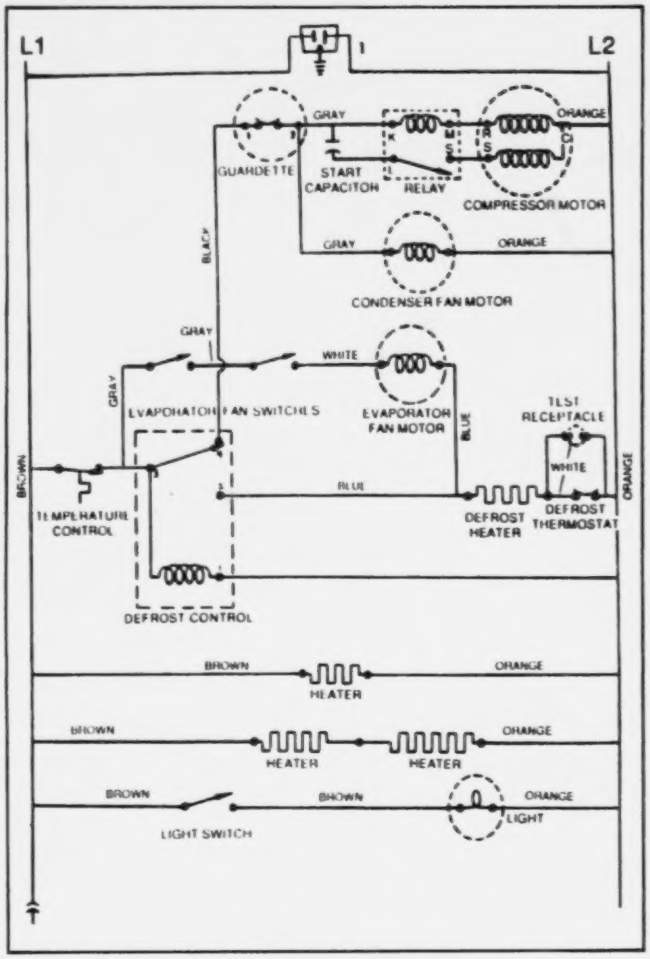
HEATER
HEATER
LIGHT SWITCH
LIGHT

Symptom: **The Compressor Tries to Start but Doesn't, It Hums Then Shuts Off On the Overload.**

1. Because the compressor tries to start, many of the components in the load circuit can be eliminated automatically.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LIGHT SWITCH
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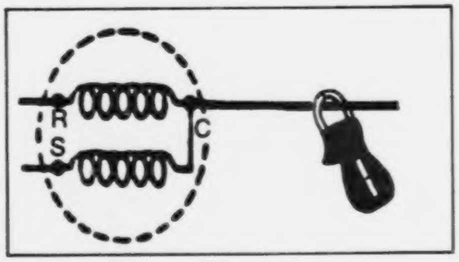
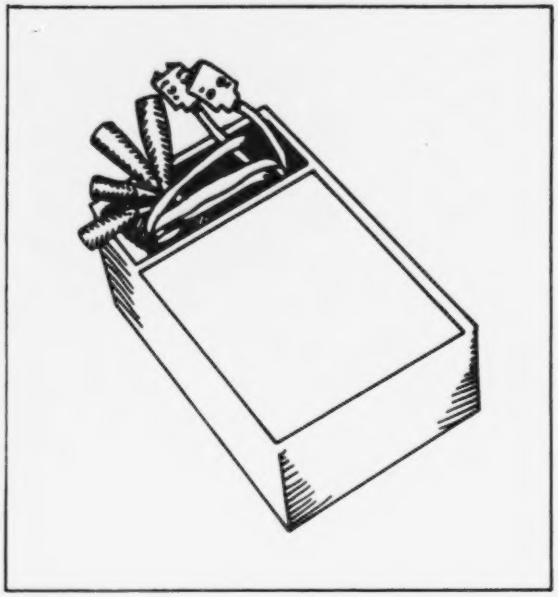
ORANGE

2. The electrical problems causing this condition are: open or shorted, start or run winding in the compressor motor, open or stuck closed relay contacts, or open relay coil.

3. We do not need to check for potential at the compressor, because it is trying to run. Attach the clamp-around ammeter on the common terminal wire. Check the amperage when the compressor tries to start. Compare this reading with the LRA amperage of the compressor.

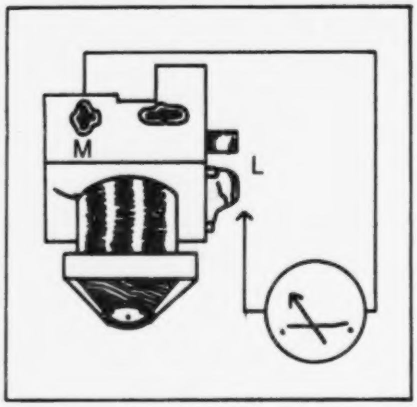


4. If the reading is slightly less than the LRA rating, the problem probably is the relay, not the compressor. However, it will take only a few minutes to check the compressor to make certain.



5. If you "ohm out" the compressor windings and still cannot make a diagnosis, you may wish to use the hermetic analyzer or test cord and jumper to start the compressor. Ask your instructor to assist you.

6. An open relay coil can be checked by setting the multimeter on RX1 and attaching the leads on terminals L1 and M of the relay. Some relays may not have these markings. In this case, examine the relay and place the meter leads on each end of the relay coil. Meter needle movement indicates **continuity**, a term that means a circuit exists.



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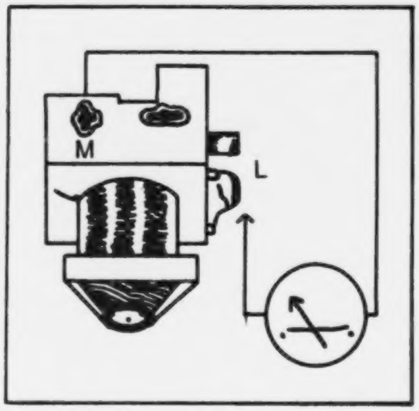
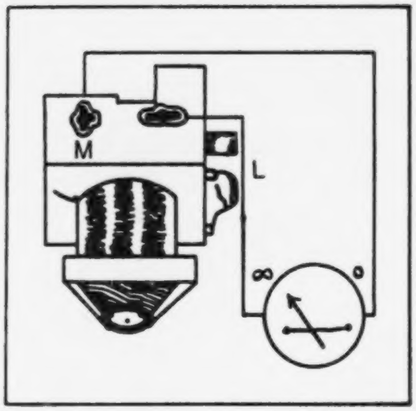


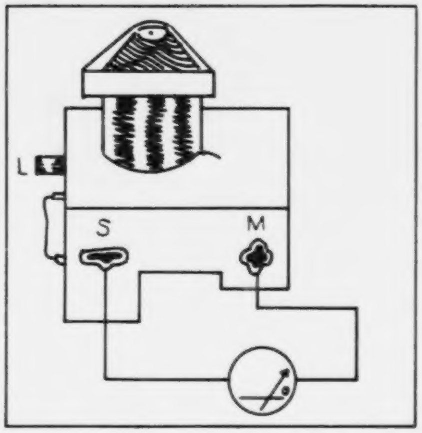
7. No needle movement indicates an open coil and the relay must be replaced. Make certain the replacement relay is correct for this compressor. Many relays may look similar but are for a different size.

8. Open or stuck contacts are also checked with the multimeter set on RX1. The contacts of a current relay should be open. Close when the compressor pulls high amperage. Then drop the start winding of the compressor out of the circuit after the compressor motor is running.



9. Place one meter lead on M or the terminal that plugs onto the run terminal of the compressor. Place the other meter lead on the S terminal. You should **NOT** have continuity at this time. The contacts should be open. Continuity indicates stuck contacts and the relay should be replaced.

10. If the contacts are not stuck, turn the relay upside-down and note the meter reaction. Now you should have continuity. Why? Ask your instructor to explain why you turn the relay upside-down.

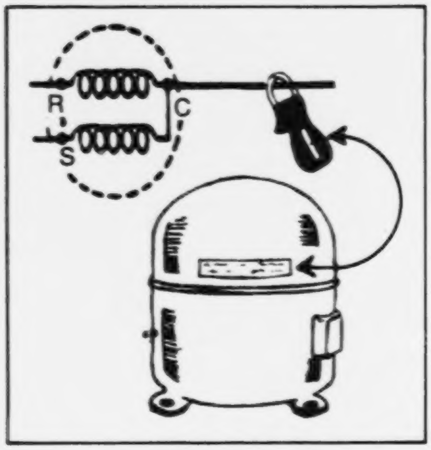


Symptom: The Compressor Runs For a Short Time and Shuts Off On the Overload.

This condition can also be a "short cycling" if the overload is automatic reset, which most domestic refrigerators use. Some problem or condition causes the compressor to use too much amperage or overheat. The overload reacts as designed and opens the circuit to the compressor. This problem or condition is often NOT electrical. However, this unit is devoted to electrical troubleshooting (mechanical is discussed in another unit).

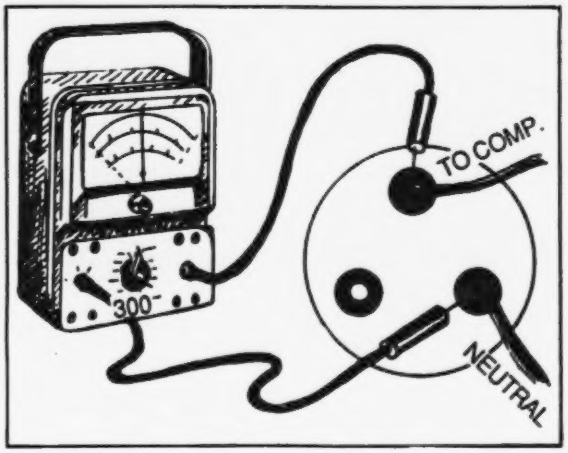
1. After visual inspection and observation you determine that the system runs for a short time and shuts off. After a short time, it restarts. Do not automatically assume the system is shutting off on the overload.

2. Attach the clamp-around ammeter on the common compressor terminal wire and measure the compressor running amperage. Compare the amperage reading with the listed run amperage on the compressor plate.



3. If this reading is higher than the rating, there is a problem causing this situation, and the compressor is probably shutting off on the overload.

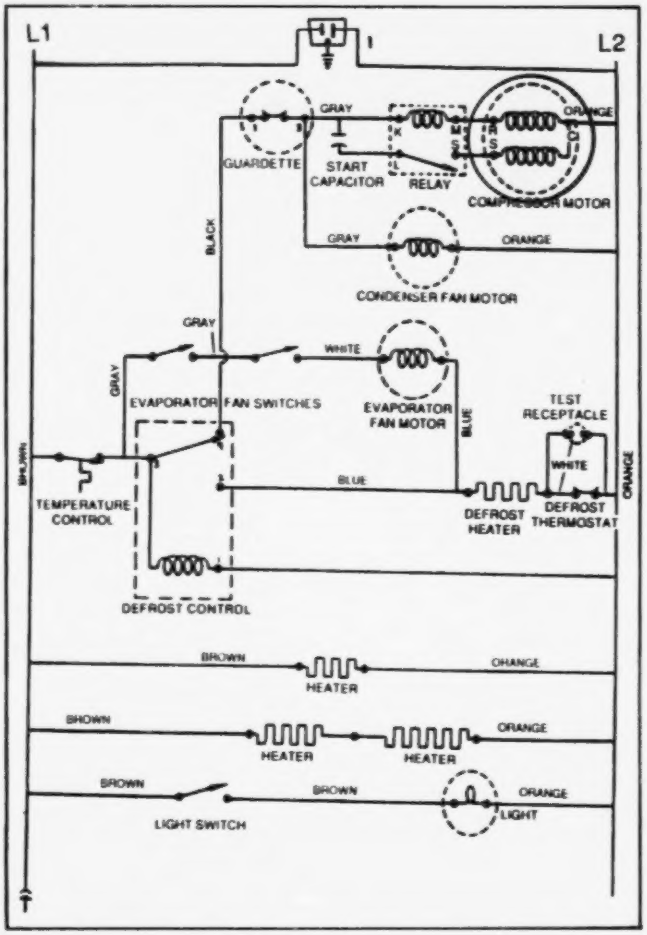
4. Check for short cycling on the overload by attaching the leads of the multimeter on both terminals of the overload with the meter set on a voltage scale high enough to avoid meter damage.



5. While the compressor is operating, the multimeter should NOT have needle movement. If the compressor cycles on the overload, the needle WILL indicate voltage. Remember this was discussed earlier. The overload is a switch, and an open switch will indicate voltage when checked across the terminals.

6. Just because the compressor cycles off on the overload, this does not indicate a bad overload. This was the reason we checked the amperage in step 2. If the overload cycled when the amperage was above the stated operating amps, the overload is doing its job. The problem is elsewhere.

7. In looking at the diagram, no other components in the compressor load circuit could cause high amperage except the compressor itself. The compressor must be checked for shorts and possible mechanical problems (as discussed in another unit).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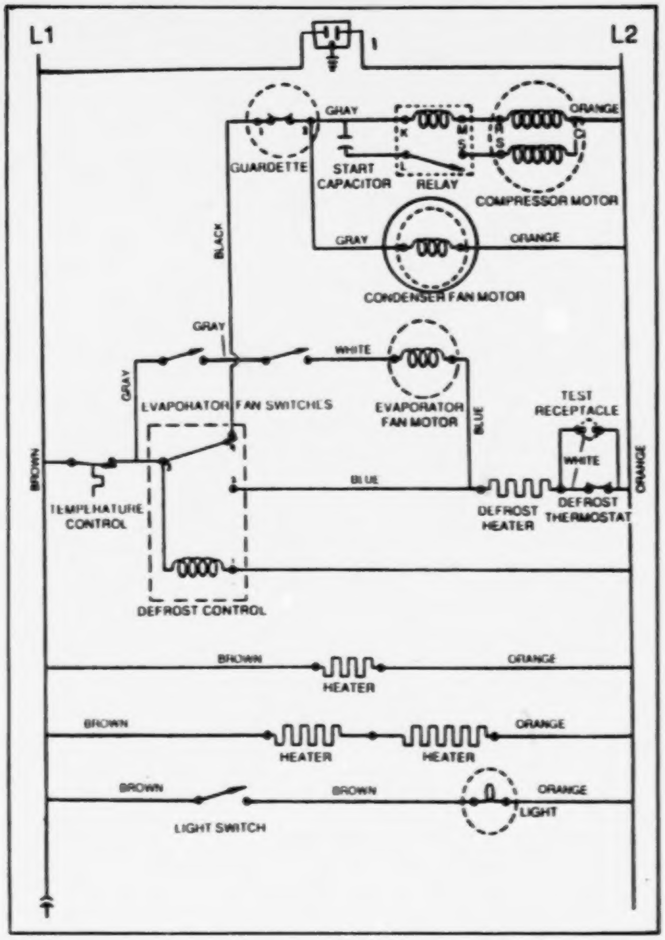
ORANGE
LIGHT

8. There is another possible problem. If a condenser fan is used, the failure of the fan will cause high head pressure. This in turn causes the compressor to work harder. The increased work is expressed by higher than normal compressor amperage. The condenser fan should be checked for operation. Do not overlook a possible refrigerant overcharge if the unit has been serviced recently.

DO SKILL SHEET 1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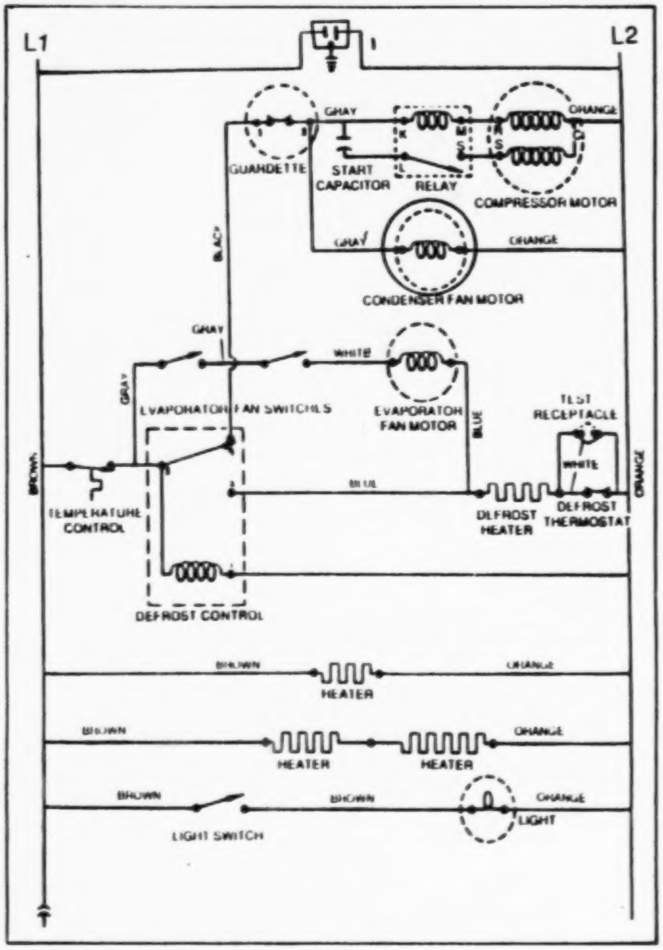
SKILL SHEET 1

Directions: Using the wiring diagram below, list all the loads in the diagram. They do not have to be in any particular order.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6. ______________________

7. ______________________

TROUBLESHOOTING ELECTRICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

UNIT REVIEW

Directions: Answer the questions below.

1. A conductor is usually used as the current path from the voltage source to the load.

   TRUE FALSE

2. A switch in a circuit is considered to be a load.

   TRUE FALSE

3. A megometer is used to determine if voltage is present in a circuit.

   TRUE FALSE

4. A voltmeter will allow a technician to check potential difference across a load.

   TRUE FALSE

5. If a switch is open, the voltmeter will read the voltage across the switch.

   TRUE FALSE

6. A defrost termination thermostat normally closes at

   a. 0 degrees F
   b. 15 degrees F
   c. 31 degrees F
   d. 40 degrees F

7. If the compressor does not try to start, there is no hum and no lights in the refrigerator, the first thing to check is the

   a. compressor.
   b. relay.
   c. thermostat.
   d. voltage source.

8. With a current relay turned upside down, and with the ohm meter probes in M and S, the technician should not read any resistance if the relay is __________ .

a.	bad	b.	good
c.	neutral	d.	ugly

9. A current relay's contacts are normally open.

TRUE FALSE

TROUBLESHOOTING ELECTRICAL PROBLEMS IN DOMESTIC REFRIGERATION SYSTEMS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Apply the principles of electrical troubleshooting to diagnose and repair domestic systems.			
2. Use **SAFE TECHNIQUES** when working in hazardous situations.			
3. Analyze system operation from electrical diagrams.			
4. Use electrical test equipment to diagnose.			

Satisfactory - Should Move On ☐

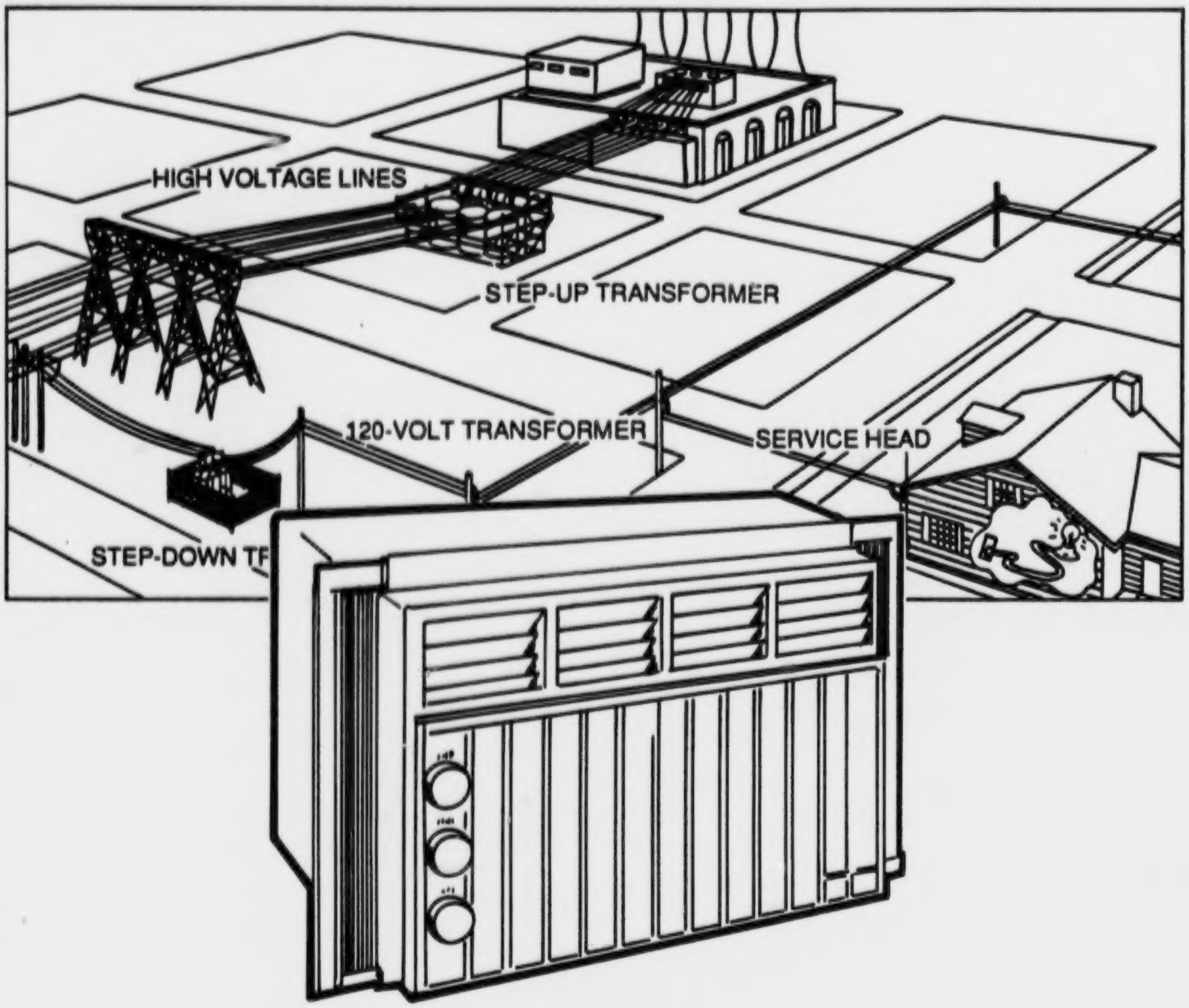
Repeat This Unit ☐

_________________________ Student's Signature/Date

_________________________ Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 9

Air Conditioning Systems

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

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AIR CONDITIONING SYSTEMS
INTRODUCTION

This unit concentrates only on summer air conditioning (cooling) equipment. Spring checkups, which include mechanical and electrical troubleshooting, are discussed. Many mechanical problems are considered refrigeration system problems; these are discussed in another unit and will not be repeated here.

(NOTE: Before beginning this unit, the student should complete the units "Troubleshooting Mechanical Problems in Domestic Refrigeration Systems" and "Troubleshooting Electrical Problems in Domestic Refrigeration Systems.")

UNIT OBJECTIVE

After completing this unit, you should be able to perform a spring checkup (including mechanical troubleshooting) on an air conditioning system and troubleshoot electrical problems.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Perform spring checkup and troubleshoot mechanical problems on window and central air conditioning systems.
2. Troubleshoot electrical air conditioning problems.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

A. Terms and Equipment

Terms

1. Ambient temperature - the surrounding temperature.
2. Defective - having something wrong; a fault or weakness.
3. Fluctuate - to keep changing; rising and falling.
4. Preventive - something that keeps problems from happening.
5. Restrict - to limit or stop something.
6. Visual inspection - looking at something carefully.

Equipment

- Flat blade screwdriver
- Phillips screwdriver
- Nut driver set
- Refrigeration thermometer
- Common pliers
- Cup of ice
- Oil can
- Manifold gauges
- Thermometer
- Garden hose
- Cup of water
- Charging manifold
- Newspaper
- Flashlight
- Needle nose pliers
- Multimeter
- Clamp-around ammeter

B. Spring checkup for Air Conditioners

Because of several factors such as length of winter, severe weather, and approaching hot weather, the air conditioning contractor recommends spring air conditioner checks. This is a form of preventive maintenance. But it is not an intensive preventive maintenance. The spring check is used to determine if the system will operate, to perform minor repairs (if needed) and to clean the unit. (NOTE: Ask your instructor for a complete preventive maintenance list so you can compare it with a spring checkup.)

In this section you will learn to:

1. Determine if the fan motor requires lubrication (oiling).
2. Quick-check the refrigerant level.
3. Replace air filters.
4. Adjust belt tension.
5. Measure temperature difference.
6. Check condensate drains.
7. Cycle system on thermostat.

Tools Needed

Flat blade screwdriver
Phillips screwdriver
Nut driver set
Refrigeration thermometer
Common pliers
Cup of ice
Oil can

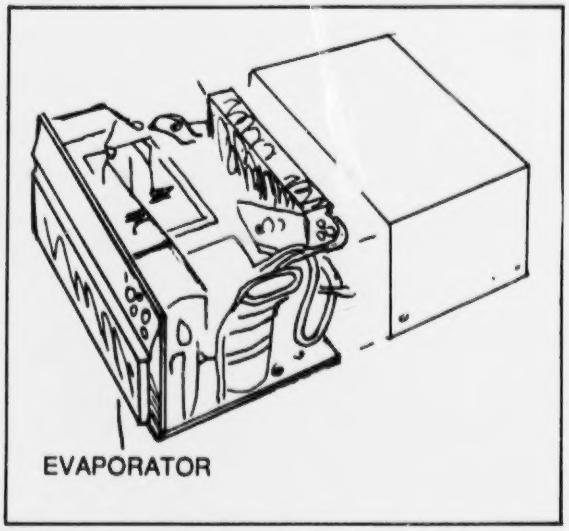
Garden hose
Cup of water
Charging manifold
Newspaper
Flashlight
Needle nose pliers

(NOTE: Different steps of procedure are described for window and central air conditioning units.)

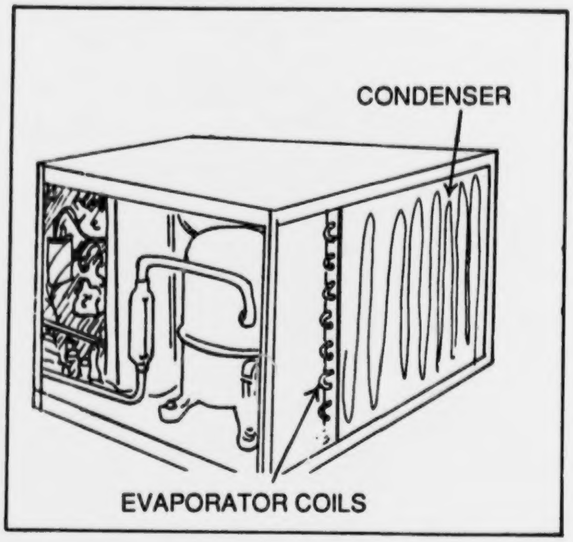
Steps of Procedure for Window Units

1. Remove the outside and inside covers if used, or slide unit out of case.

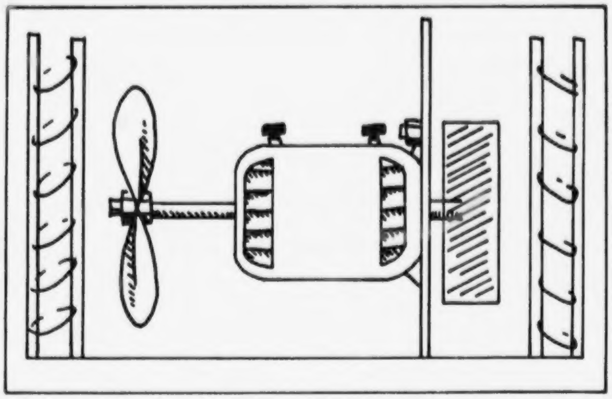
   CAUTION: Do **NOT** completely slide the unit out of the case, only far enough to allow service to the fan motor at this time.



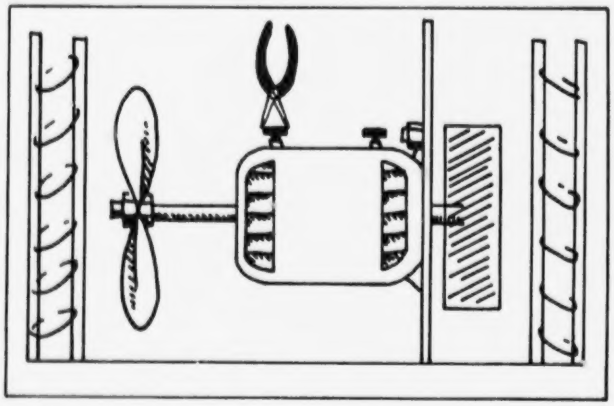
2. Visually inspect the outside surface of the condenser and evaporator coils for possible damage and bent fins.



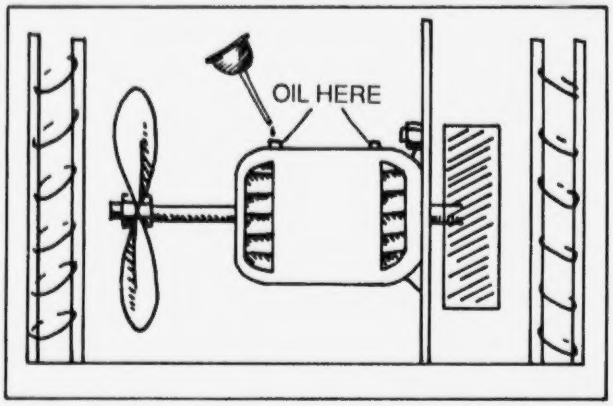
4. Inspect the fan motor and determine the location of oil ports in each end of the motor. Usually the oil ports are located on top of each end bell and have some sort of dust cover. If the motor has sealed bearings, lubrication is not necessary.



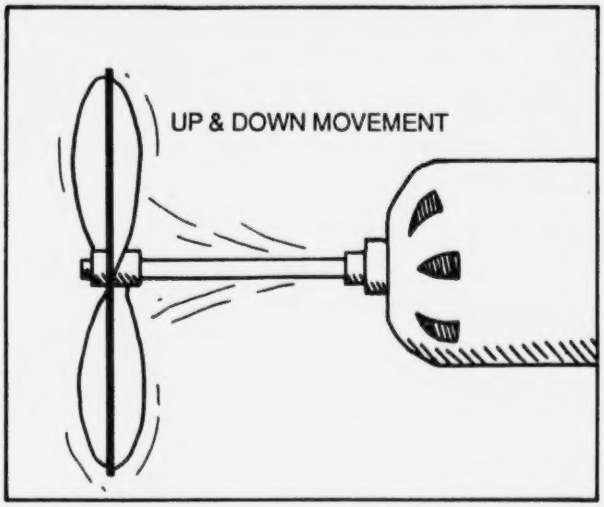
5. Remove the oil port dust covers. The covers may be metal, plastic, or rubber. Be careful not to lose or break the covers. Use needle nose pliers to gently loosen the covers and remove them from the oil port.



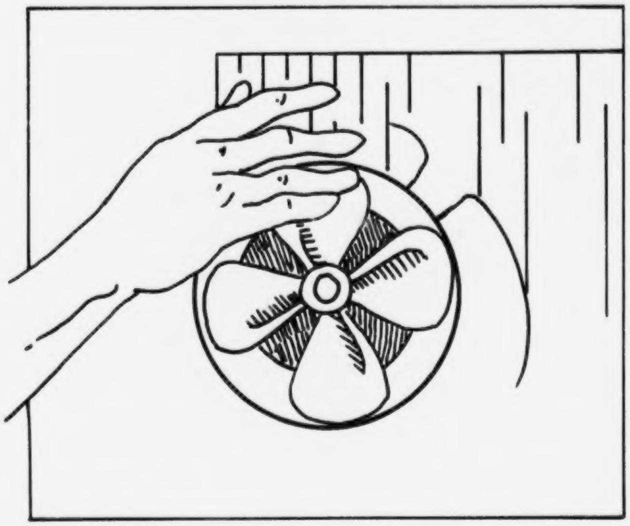
6. Use an oil can filled with common 30 weight motor oil. Make certain each port has several drops. Be careful not to over lubricate.



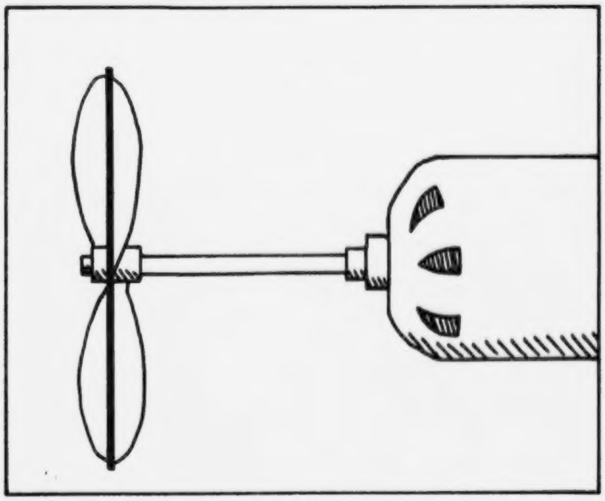
7. Ask your instructor to explain how to check for bearings wear at this time.



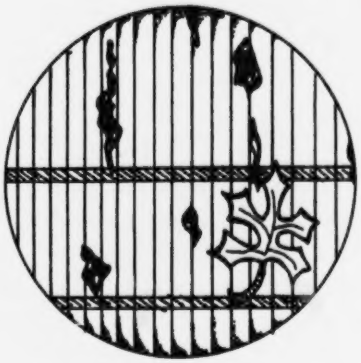
8. Rotate the motor shaft by hand to determine if the fan blades are hitting anything and are properly aligned.



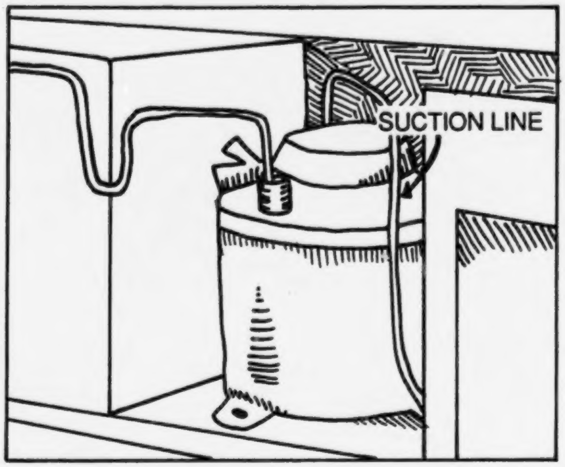
9. Notice that the condenser fan is a propeller type with a slinger ring attached to each blade. This ring dips into the condensate water in the bottom of the air conditioner and splashes water on the condenser coil.



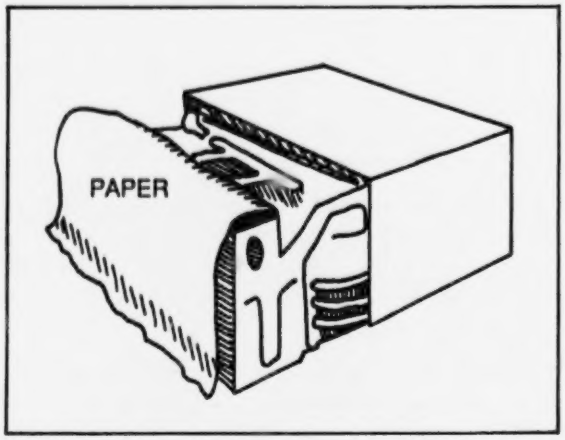
10. Using a flashlight or dropcord, inspect the inside of the condenser coil for dirt, leaves, and anything that may restrict air flow. The system will not operate properly if it is dirty. The best method of cleaning a dirty condenser coil is to get help, remove the unit completely from the case, and take the unit to the local car wash.



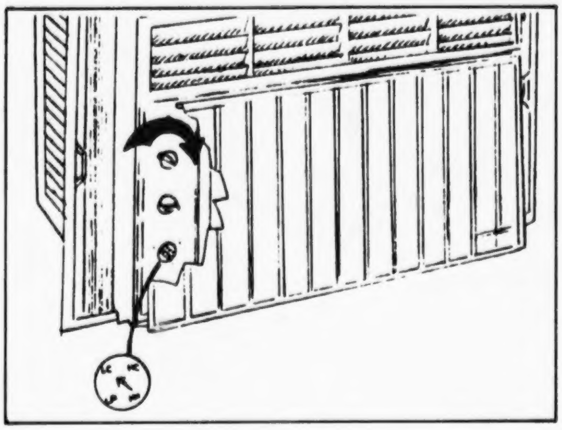
11. If the coil is clean, slide the unit partially back into the case, but leave enough room to see the suction line going to the compressor.



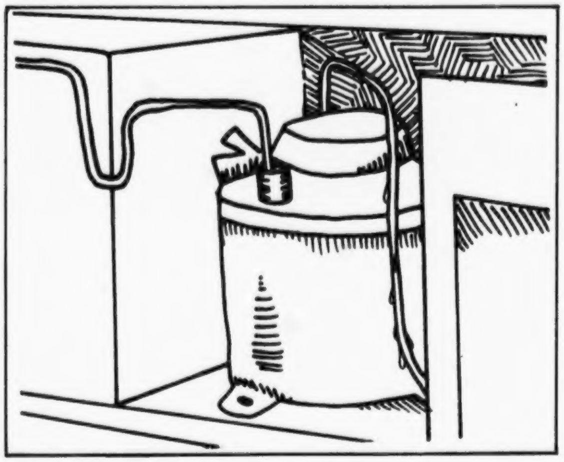
12. Quick-check the refrigerant level by placing a newspaper over the evaporator, completely restricting the air flow. Read steps 13 through 17 **BEFORE** starting the system.



13. Turn the thermostat to maximum cooling position (as cold as it will go).



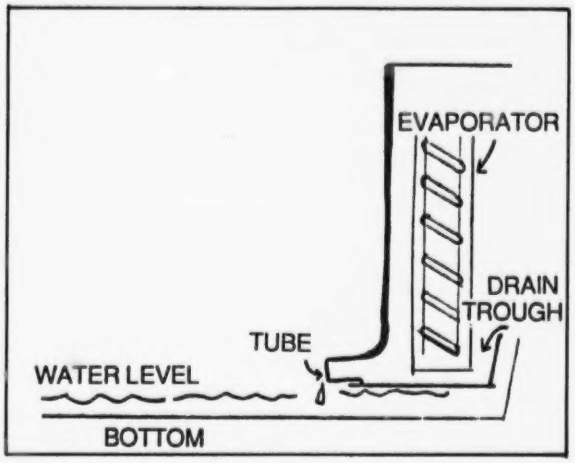
14. Turn the window unit on at low cool position.



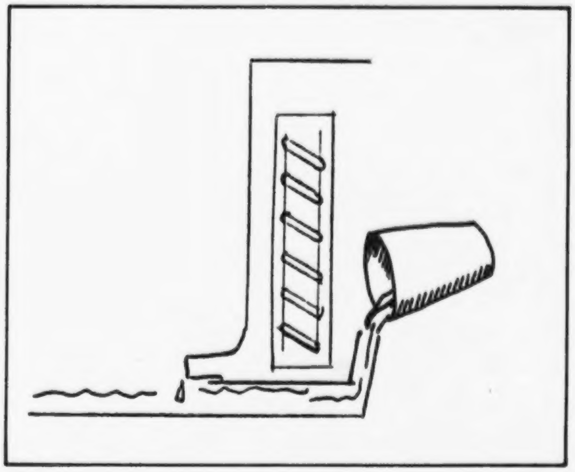
15. Carefully observe the suction line for sweating and frost.

16. With restricted air flow, the low side will frost at the level of refrigerant.

17. A properly charged system will have frost appear on the suction line. This may happen fast and you should be ready to turn the system off immediately or remove the newspaper when frost first appears.

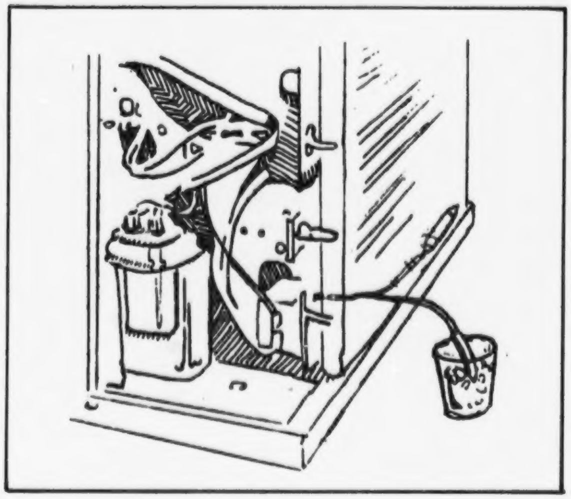


18. As stated earlier, water should be in the bottom of the air conditioner after the system has operated for some time. The amount of time and water depends upon the humidity of the air.

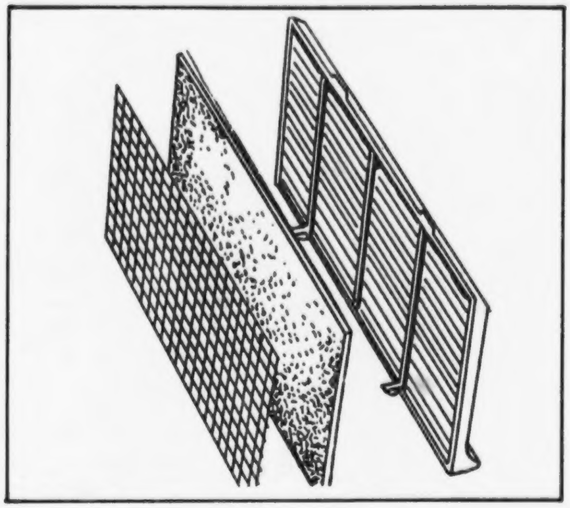


19. The evaporator has a drain trough at the bottom of the coil and a short tube which allows the water to flow to the compressor area. Visually inspect this drain for stoppage. Then pour a cup of water in the drain trough. Watch to see if the water flows through the tube.

20. Check the cycling of the thermostat by placing the thermostat control approximately mid range, but with the compressor and fan operating. Place the control bulb of the thermostat in a cup of ice. This should cause the thermostat switch to open. The compressor should shut off, but the fan will continue to run.



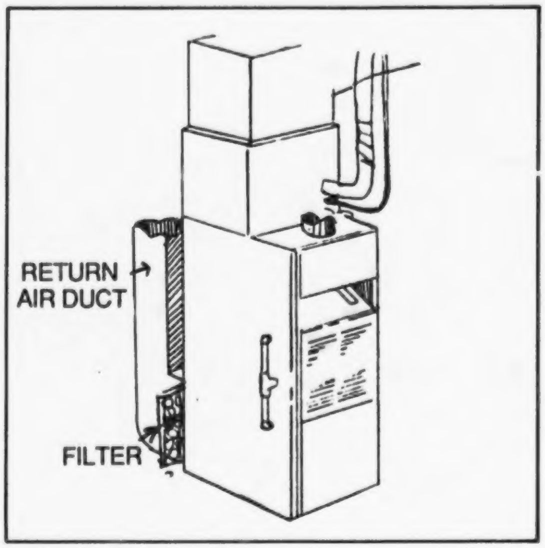
21. Window units normally use washable air filters on the evaporating coil. This filter should be washed in the kitchen sink using liquid dish detergent, and rinsed in cold water. The filter does not have to be dry to be put back on the unit.



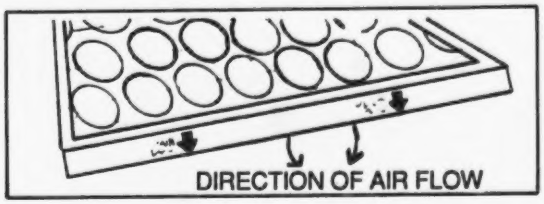
22. Slide the unit back into the case. Check the insulation around the case to make sure it is still in place and there are no air leaks. Put the front on the system and adjust the air vents.

Spring Check for Central Air Conditioners

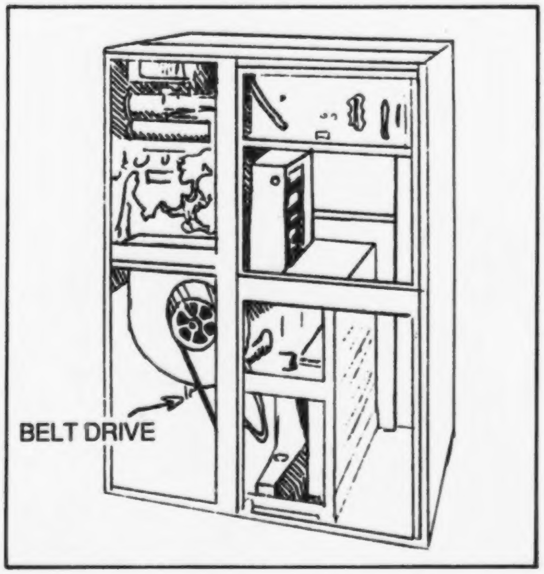
1. Find the air filter compartment. This may be located in the return air duct or in furnace. If it is in the furnace, the blower door must be removed.



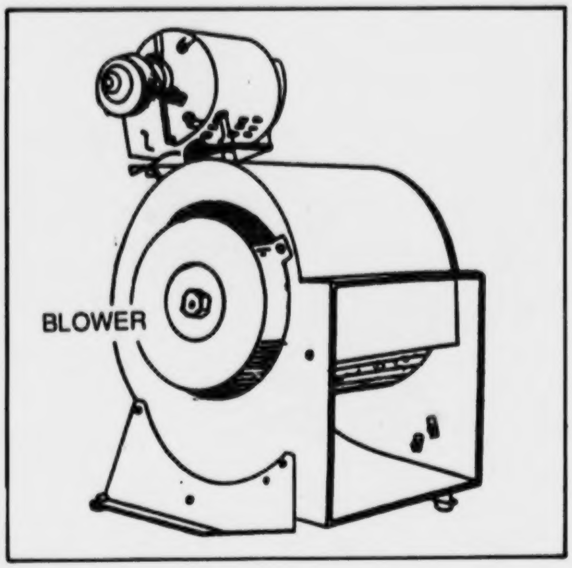
2. Replace the disposable fiberglass filter or wash, if it is a permanent type. Make certain the air flow arrows on the side of the filter point in the proper direction.



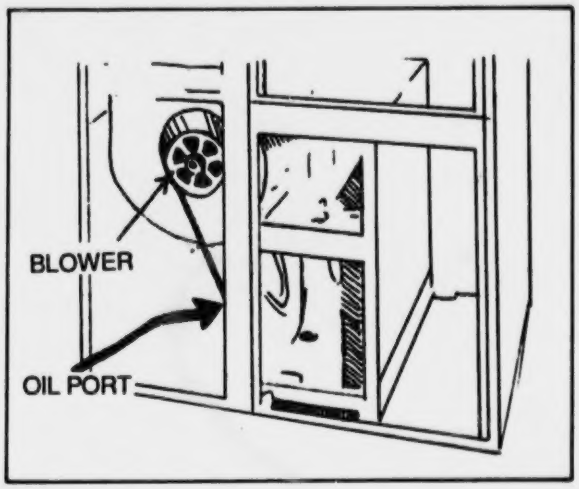
3. The furnace blower is used with the air conditioner as well as in the winter, so it should be lubricated. Determine if the blower is direct drive or blower driven.



4. Direct drive motors may have sealed bearings. If so, lubrication is not necessary.

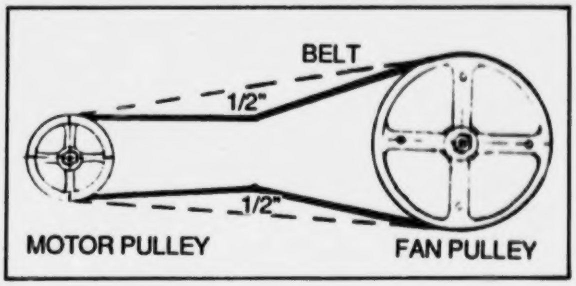


5. If the blower is direct drive and the motor does have oil ports, remove the dust covers and lubricate as with the fan motor in a window unit.

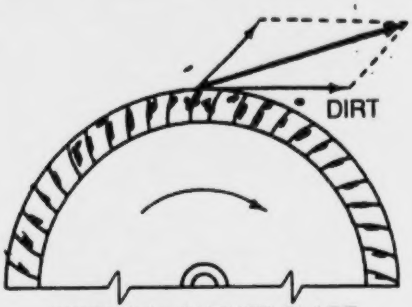


6. Belt driven blowers usually require motor lubrication in addition to the blower shaft. The pillow bearings on the blower shaft may use a high temp grease instead of oil. If it has an oil or grease cup, it must be filled.

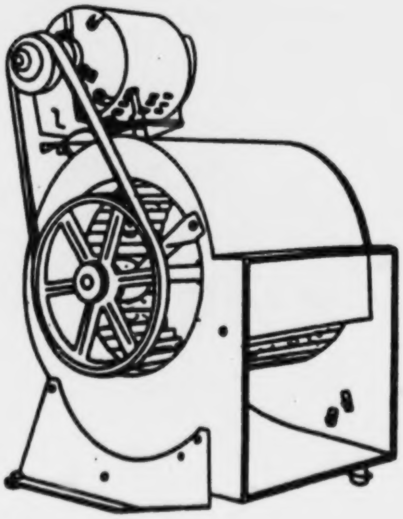
7. Check the belt tension and adjust if necessary. The belt should have 1 inch play. Be careful not to overtighten the belt which can result in bearing damage and noisy startup.



You can also use an ammeter and check motor data plate for FLA. Tighten the belt until FLA is reached and belt will have the proper tautness.

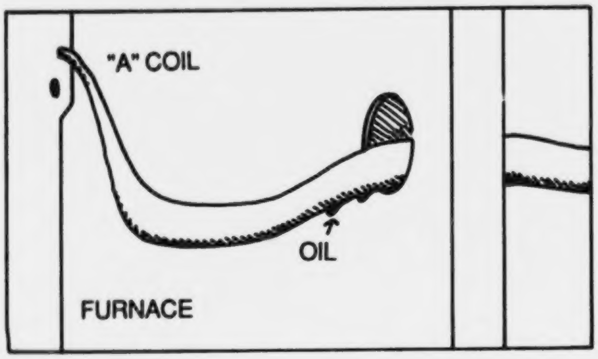


FORWARD CURVED BLADE



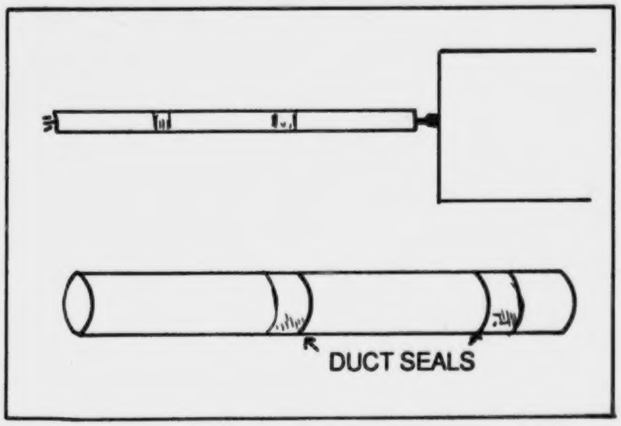
8. Visually inspect the blower for dirty fins. You will notice this fan or blower is what we call centrifugal or "squirrel cage." If the system has been operated with dirty filters or without filters, the "cup" of the fins fills up with dirt. If dirty, the blower must be removed from the furnace and the dirt removed with a wire brush or washed off.

9. Check the condenser drain for stoppage by pouring a cup of water in the evaporator drain trough or drain hose. Determine if the water goes through all the way.

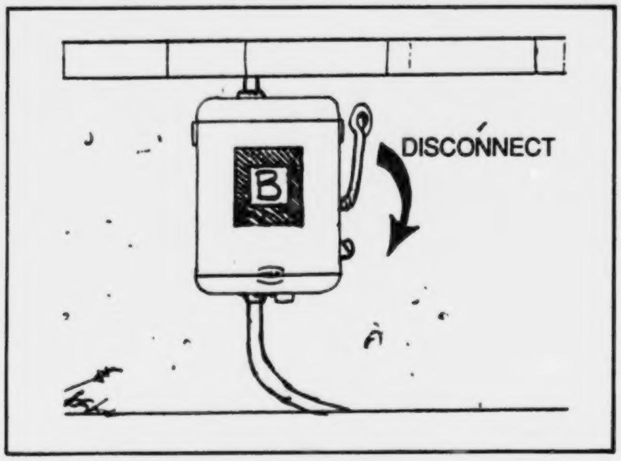


10. Visually inspect all tubing for possible refrigeration leaks.

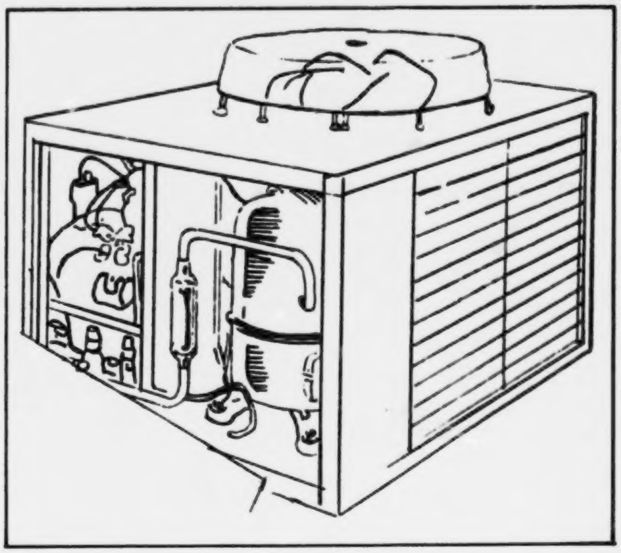
11. Visually inspect all tubing insulation and the duct to determine if a problem might exist due to loose insulation of the duct.



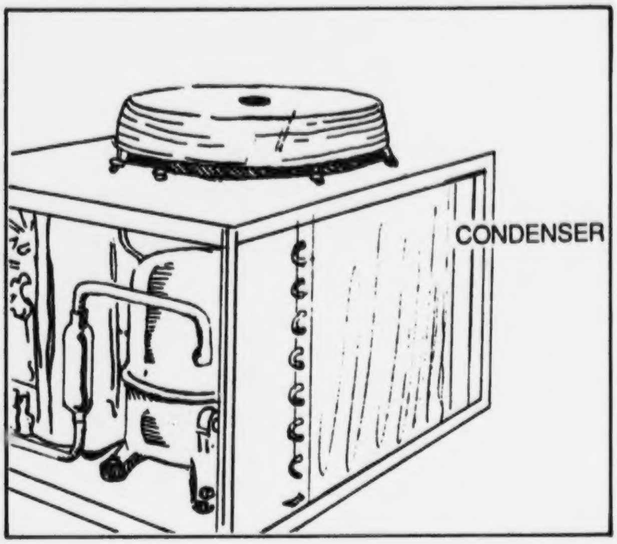
12. **GO TO THE OUTSIDE OF THE HOUSE AND DISCONNECT THE ELECTRICAL POWER TO THE CONDENSING UNIT.**



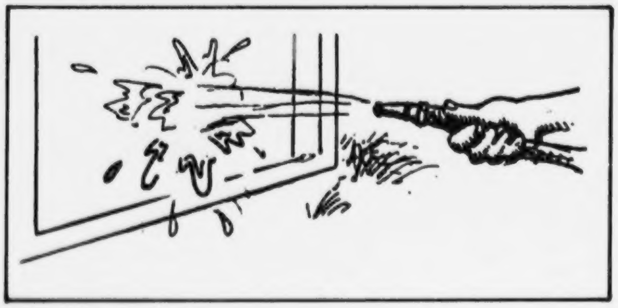
13. Remove the panels necessary to gain entry to the fan motor, compressor, controls, and condenser coil.



14. Inspect the condenser coil for any damage and dirt.



15. Use the garden hose to wash the condenser coil. Be careful not to get water into the controls. Commercially prepared coil cleaners are available. Ask your instructor about these. In washing the coil, be certain not to force the dirt back into the fins and the coil. (NOTE: Ask your instructor to show you the proper method of washing the coil.)



16. Determine if the condenser fan motor requires lubrication.

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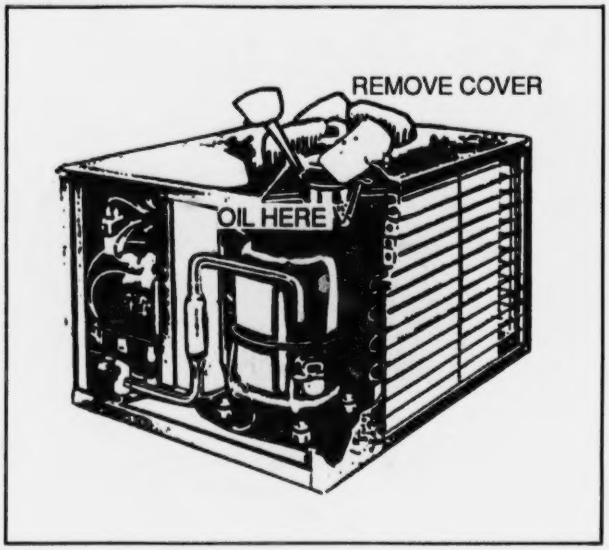
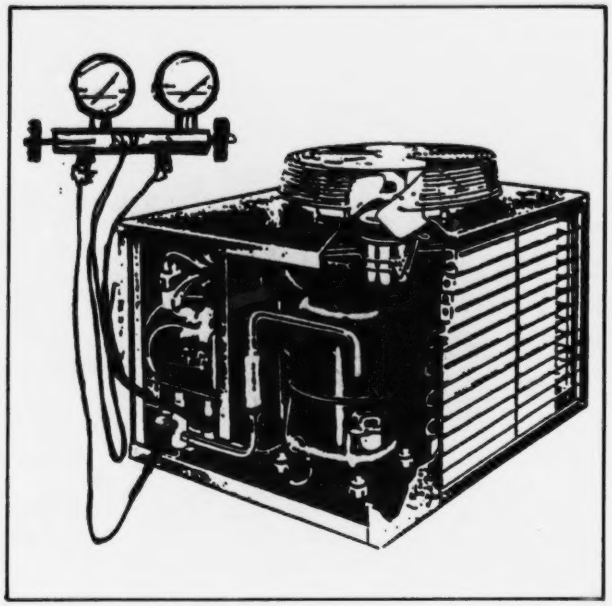
17. After lubrication of the fan motor, inspect all wiring, insulation and tubing. Make any repairs necessary. In the time required to do these things, the condenser coil should be drying (after washing). It should also be closer to ambient temperature needed for testing refrigerant level.

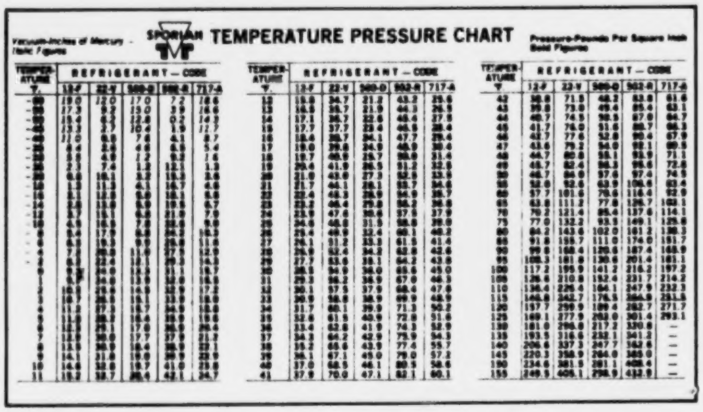


18. Install the manifold gauges on the suction and high sides of the system, using the testing ports located at the condensing unit lines.



19. Replace any panels necessary to achieve good air flow through the coil.

20. Use the ambient temperature plus 30 method to check the refrigerant charge. High efficiency units and some manufacturers use other methods. Ask your instructor about these.

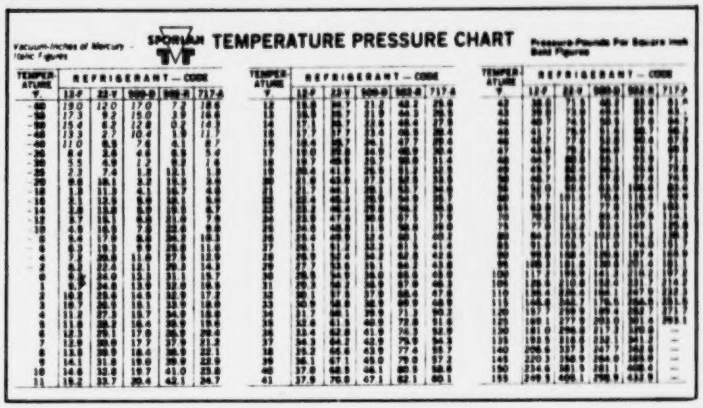


TEMPERATURE PRESSURE CHART

Vacuum-Inches of Mercury - Italic Figures

Pressure-Pounds Per Square Inch Bold Figures

21. Determine what ambient temperature, desired suction, and head pressures the unit should have for normal operation.

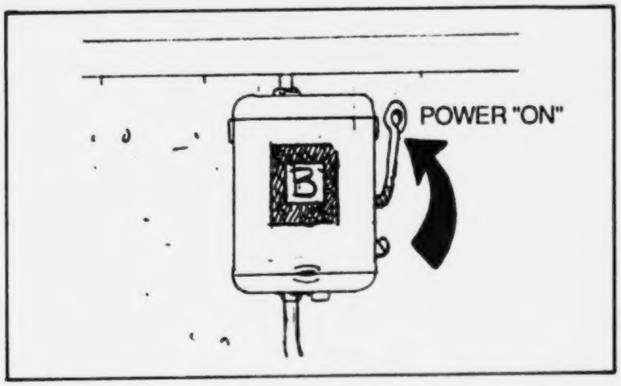


TEMPERATURE PRESSURE CHART

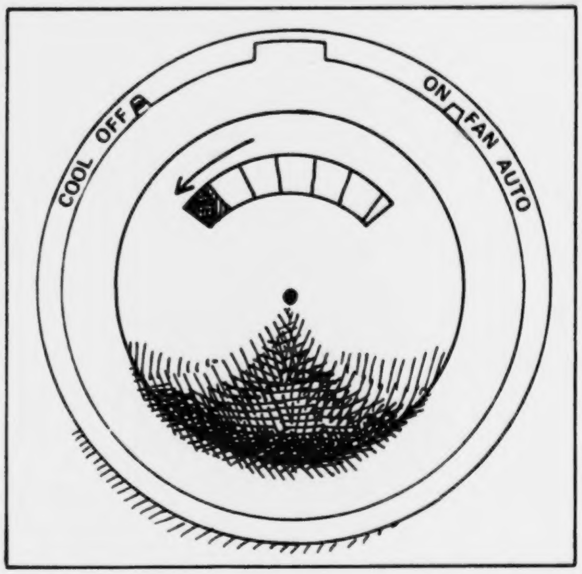
Vacuum-Inches of Mercury - Italic Figures

Pressure-Pounds Per Square Inch Bold Figures

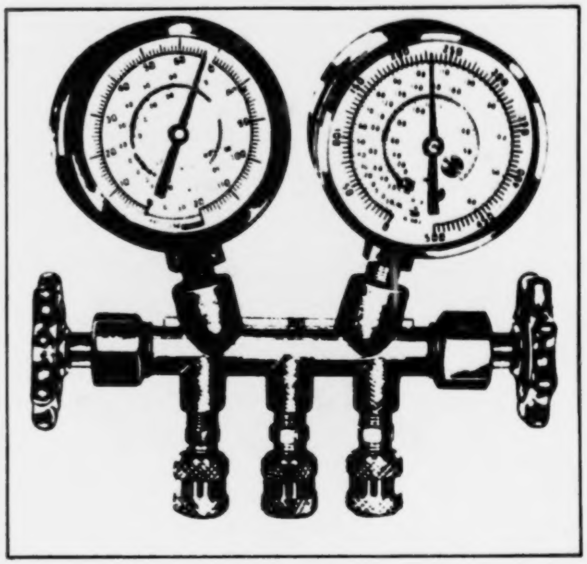
22. Close the disconnect switch, restoring electrical power to the system. **BE CAREFUL!**



23. Set the room thermostat and the lowest position.



24. Observe the gauge pressures and see if they are correct.



25. If the pressures are not correct, ask your instructor what steps to take next. Troubleshooting the problems may be necessary.

C. Troubleshooting Electrical Air Conditioning Problems

(NOTE: The instructor may wish to have the student troubleshoot on paper or set up problems using these steps of procedure.)

A cooling system using a refrigeration system (which most do) is simply one unit made up of many components, or parts, that you have learned about in other units. These components are a compressor, relay or contractor, motor, thermostat, overload and controls. This section on troubleshooting will explore the symptoms and problems found in central air conditioners.

In this section you will learn how to:

1. Determine the operation of the system by interpreting the wiring diagram.
2. Explain the operation of an air conditioning system.
3. Use symptoms and collected data to troubleshoot a system.

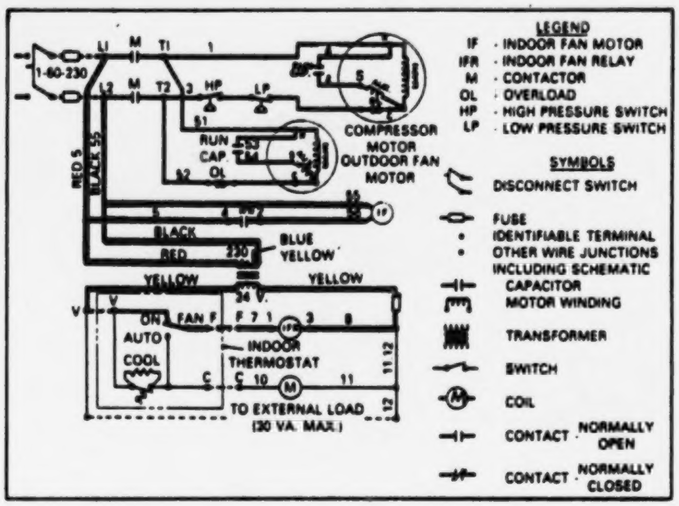
Tools Needed

Multimeter
Clamp-around ammeter
Flat blade screwdriver
Phillips screwdriver
Nut driver set

Manifold gauges
Thermometer
Needle nose pliers
Flashlight or dropcord

Symptoms: The system runs for a short time and shuts off, then comes back on. It continues to short cycle.

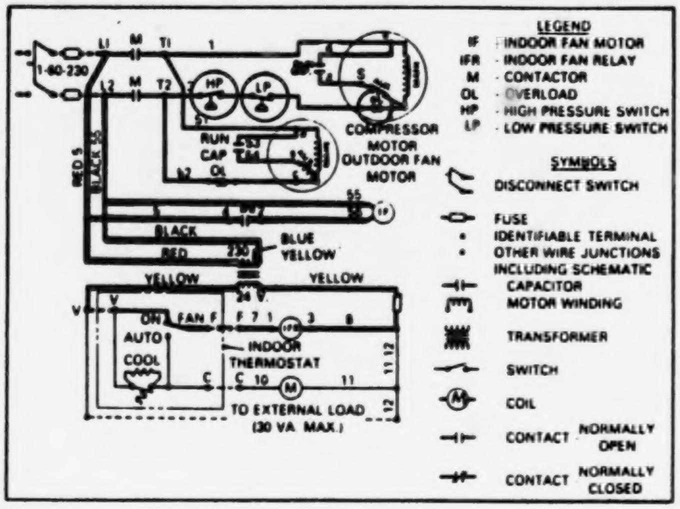
1. When observing this situation, you should determine that the furnace blower continues to operate when the condensing unit is off. Referring to the wiring diagram, this allows you to eliminate the components and wiring marked in bold.


1-60-230
L1
M
T1
1
L2
M
T2
3
HP
LP
S1
RUN CAP.
S2
OL
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RED 5
BLACK 55
5
4
IFR
2
55
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V.
V
V
ON
FAN F
F 7 1
IFR
3
8
AUTO
COOL
INDOOR THERMOSTAT
C
C 10
M
11
11 12
12
TO EXTERNAL LOAD (30 VA. MAX.)
LEGEND
IF - INDOOR FAN MOTOR
IFR - INDOOR FAN RELAY
M - CONTACTOR
OL - OVERLOAD
HP - HIGH PRESSURE SWITCH
LP - LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
FUSE
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT - NORMALLY OPEN
CONTACT - NORMALLY CLOSED

2. The problem that you now have is eliminating even more components, so that you can make the diagnosis. Because the system is short cycling, the problem must be in some sort of a component that resets itself or the problem is corrected for a short time. Look at the diagram; do you see anything like this?

3. Remember what you have learned about electrical troubleshooting with loads and switches. (You may wish to review the unit on Troubleshooting Electrical Problems in Domestic Refrigeration Systems.)

   It looks like the possibilities are the overload, low pressure switch, or high pressure switch. Any one of these will allow short cycling.


1-60-230
L1
M
T1
1
L2
M
T2
HP
LP
S
T4
S1
COMPRESSOR MOTOR
RUN CAP
OL
OUTDOOR FAN MOTOR
RED 5
BLACK 55
55
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V.
V
V
ON
FAN F
F 7 1
IFR
3
8
AUTO
COOL
INDOOR THERMOSTAT
C
C 10
M
11
11 12
12
TO EXTERNAL LOAD (30 VA MAX.)
LEGEND
IF - INDOOR FAN MOTOR
IFR - INDOOR FAN RELAY
M - CONTACTOR
OL - OVERLOAD
HP - HIGH PRESSURE SWITCH
LP - LOW PRESSURE SWITCH
SYMBOLS
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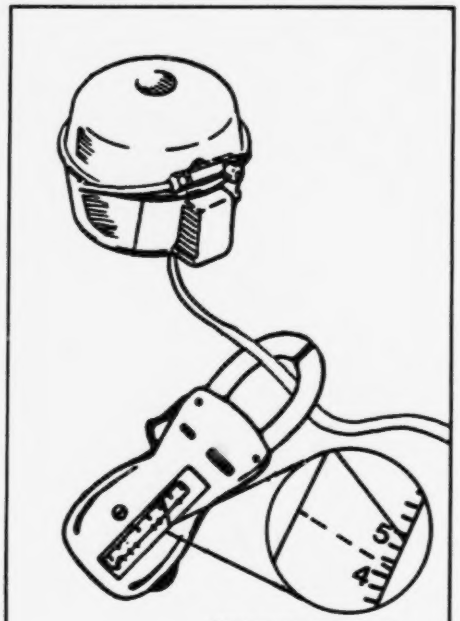
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

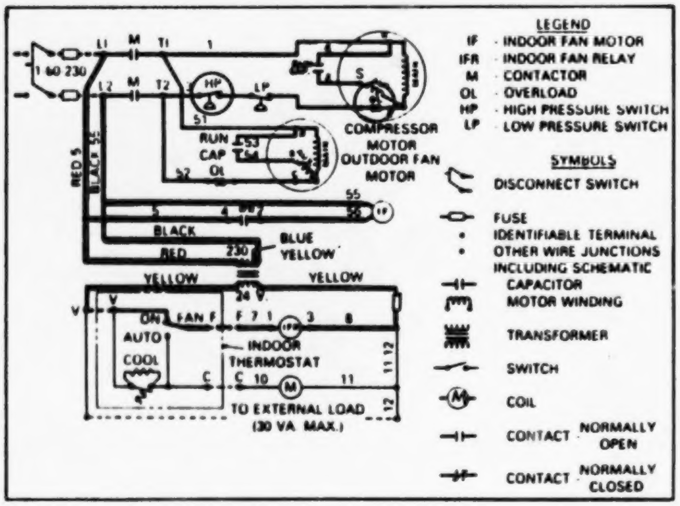
4. If the overload is opening the circuit, it must be because of too much current or heat. Measure the compressor amperage with the clamp-around ammeter on the common compressor wire. Is the amperage reading too high? What should it be? How do you determine this? Does FLA or LRA mean anything to you?



READS NORMAL

5. Many things can cause compressor current to be high. However, low pressure is NOT one of them. If the amperage is too high, you can eliminate the low pressure switch.

6. This still leaves two components: high pressure switch and overload. Both are protective devices and simply react to a system problem. The high pressure switch is probably the easiest to check. Set the multimeter on 300 volt scale and place a lead on each terminal of the high pressure switch. What do you observe? Is the voltage constant or fluctuating (first you have the voltage and then you don't)?


L1
M
T1
1
1-60-230
L2
M
T2
HP
LP
S
S1
RUN CAP
S3
S4
S2
OL
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RED S
BLACK S5
S5
5
4
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
V
ON
FAN
F
AUTO
COOL
C
INDOOR THERMOSTAT
IFR
3
8
10
M
11
11 12
12
TO EXTERNAL LOAD (30 VA MAX.)
LEGEND
IF - INDOOR FAN MOTOR
IFR - INDOOR FAN RELAY
M - CONTACTOR
OL - OVERLOAD
HP - HIGH PRESSURE SWITCH
LP - LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
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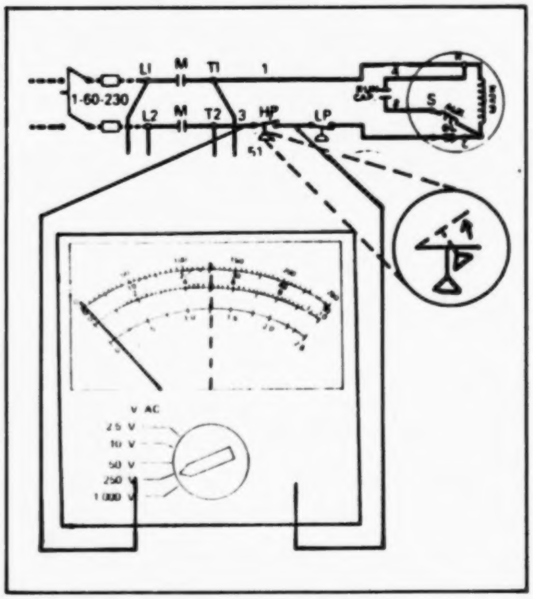
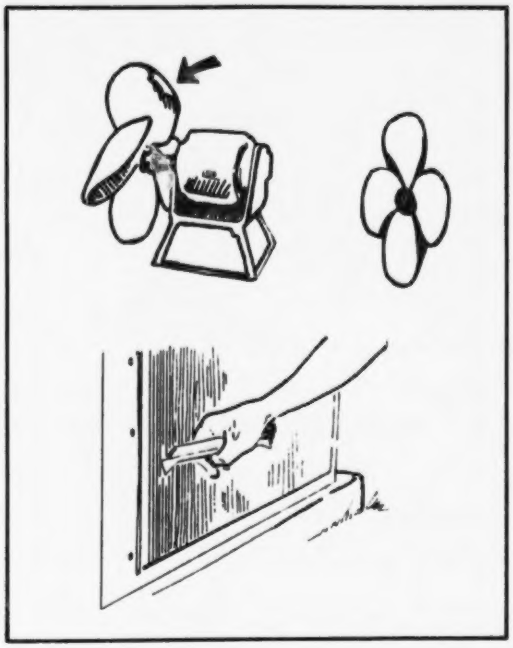
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT - NORMALLY OPEN
CONTACT - NORMALLY CLOSED

7. Further observation reveals that when the system is operating, you don't have voltage across the switch and when the system is off, you do have voltage across the switch. Remember what you have learned about testing across a switch.

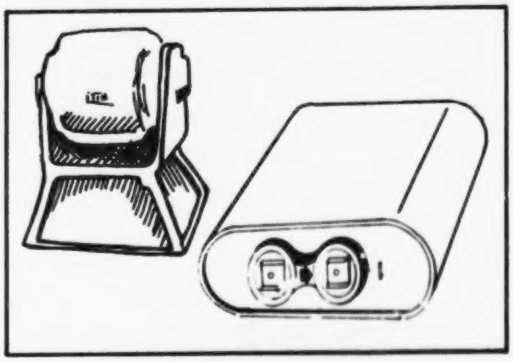

L1
M
T1
1
1-60-230
L2
M
T2
3
HP
LP
S
S1
V AC
2.5 V
10 V
50 V
250 V
1 000 V

8. This check means the pressure switch is opening and closing. The problem could be anything that will cause restricted air flow across the condenser coil.

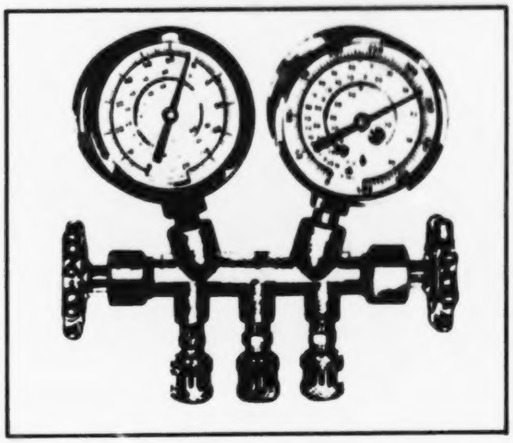
9. Possible mechanical problems: dirty condenser, fan belt, fan blades, bent or damaged coil fins, stuck fan motor. Check these.



10. Possible electrical problems: fan motor capacitor, pressure switch.



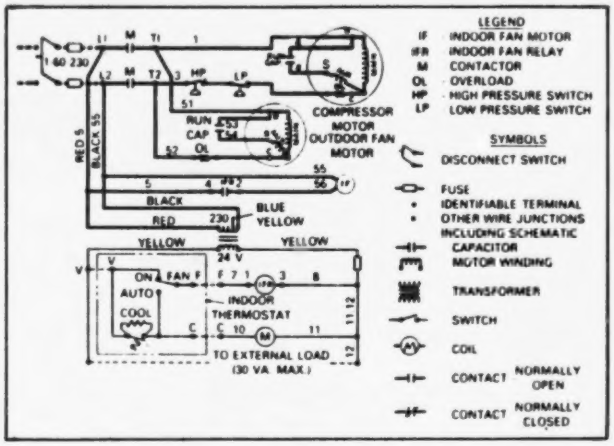
11. The pressure itself could be defective. Attach the gauges on the high side of the system and determine if the system has high head pressure. If not, and the switch is still opening and closing, replace the switch.



12. High amperage accompanies high head pressure. If the amperage check earlier indicated high amperage, step 11 would not be necessary.

Symptom: A slight hum is heard in the condensing unit but nothing in the unit works. The furnace blower operates.

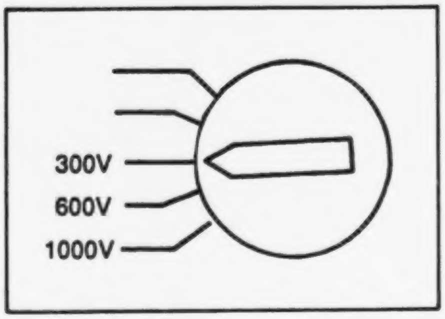
1. You have two different voltage sources going to the condensing unit, 24 volt control and 240 volt. Locate these on the diagram.


L1
M
T1
1
1 60 230
L2
M
T2
3
HP
LP
51
RUN
CAP
53
54
52
OL
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RED 5
BLACK 55
55
5
4
2
56
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
V
V
ON
FAN
F
AUTO
COOL
F 7 1
IFR
3
8
INDOOR THERMOSTAT
11 12
C
C 10
M
11
TO EXTERNAL LOAD (30 VA MAX.)
12
LEGEND
IF · INDOOR FAN MOTOR
IFR · INDOOR FAN RELAY
M · CONTACTOR
OL · OVERLOAD
HP · HIGH PRESSURE SWITCH
LP · LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
FUSE
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

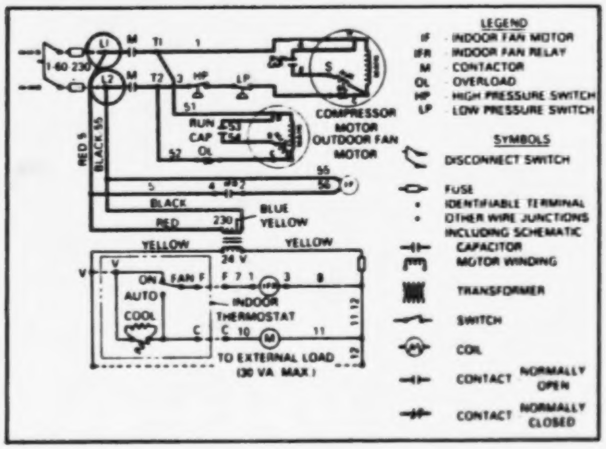
2. What component in the condensing unit is using 24 voltage?

3. The contactor coil is energized by 24 volts coming from the furnace transformer. The hum would indicate the contactor coil is being energized, but the 240 volts used by the contactor contacts is the problem.

4. Place the multimeter voltage scale on 300 volts and check the terminals on the contactor.


300V
600V
1000V

5. Zero volts on the power supply line of the contactor indicates that no voltage is coming to the condensing unit.


L1
L2
M
T1
T2
1
3
HP
LP
1-60 230
S
51
52
RUN
CAP
53
54
OL
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RED 5
BLACK 55
55
56
5
4
2
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
V
ON
FAN F
AUTO
COOL
C
F 7 1
IFR
3
8
INDOOR THERMOSTAT
C 10
M
11
11 12
12
TO EXTERNAL LOAD (30 VA MAX)
LEGEND
IF - INDOOR FAN MOTOR
IFR - INDOOR FAN RELAY
M - CONTACTOR
OL - OVERLOAD
HP - HIGH PRESSURE SWITCH
LP - LOW PRESSURE SWITCH
SYMBOLS
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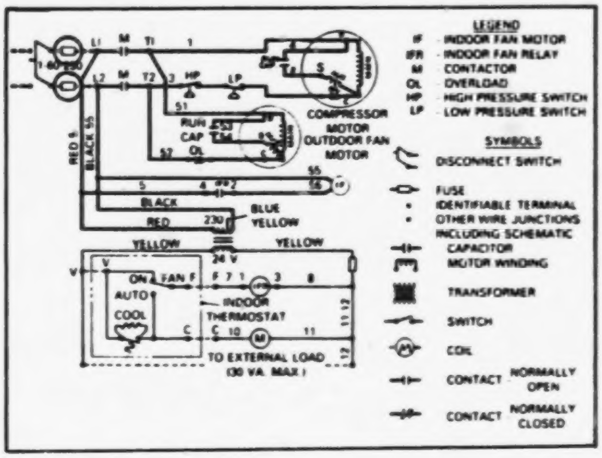
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

6. Check the fuses or circuit breaker in the house wiring.


L1
L2
M
T1
T2
1
3
HP
LP
1-60 230
S
51
52
RUN
CAP
53
54
OL
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RED 5
BLACK 55
55
56
5
4
2
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
V
ON
FAN F
AUTO
COOL
C
F 7 1
IFR
3
8
INDOOR THERMOSTAT
C 10
M
11
11 12
12
TO EXTERNAL LOAD (30 VA MAX)
LEGEND
IF - INDOOR FAN MOTOR
IFR - INDOOR FAN RELAY
M - CONTACTOR
OL - OVERLOAD
HP - HIGH PRESSURE SWITCH
LP - LOW PRESSURE SWITCH
SYMBOLS
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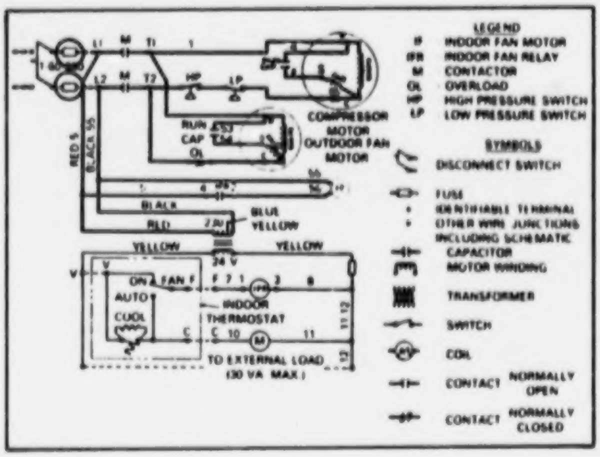
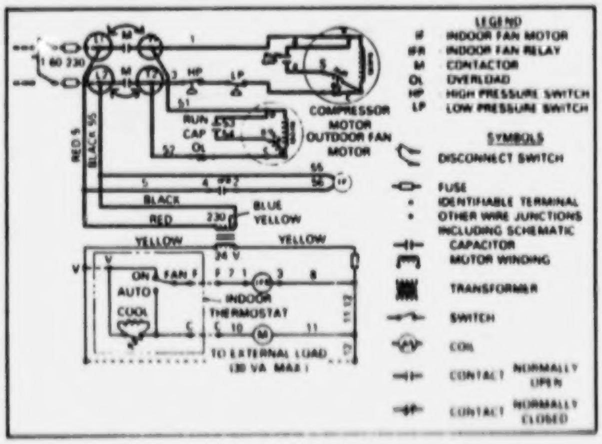
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

Symptom: Nothing in the condensing unit operates, but the furnace blower operates.

1. Place the multimeter on 300 volt scale and check for voltage on the power line of the contactor.


L1
M
T1
1
L2
M
T2
HP
LP
RUN
CAP
OL
COMPRESSOR
MOTOR
OUTDOOR FAN
MOTOR
RED 5
BLACK 55
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
V
ON
FAN F
AUTO
COOL
C
F 7 1
IFR
3
8
INDOOR
THERMOSTAT
C 10
M
11
11 12
12
TO EXTERNAL LOAD
(30 VA MAX)
LEGEND
IF INDOOR FAN MOTOR
IFR INDOOR FAN RELAY
M CONTACTOR
OL OVERLOAD
HP HIGH PRESSURE SWITCH
LP LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
FUSE
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS
INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

2. A reading of 240 volts indicates electrical power is available to the contactor if the switches close.


1 60 230
M
1
M
3
HP
LP
51
RUN
CAP
52
OL
COMPRESSOR
MOTOR
OUTDOOR FAN
MOTOR
RED 5
BLACK 55
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
V
ON
FAN F
AUTO
COOL
C
F 7 1
IFR
3
8
INDOOR
THERMOSTAT
C 10
M
11
11 12
12
TO EXTERNAL LOAD
(30 VA MAX)
LEGEND
IF INDOOR FAN MOTOR
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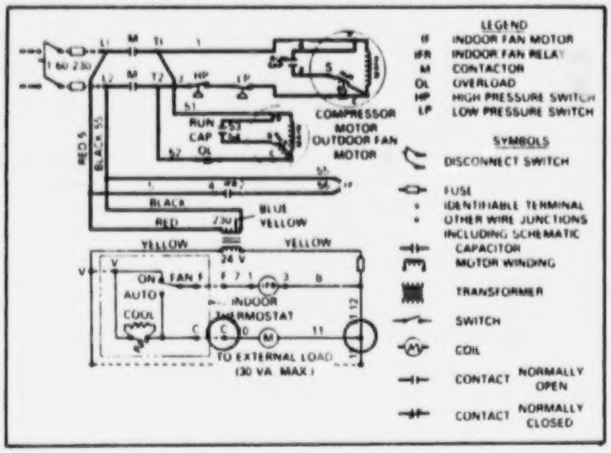
M CONTACTOR
OL OVERLOAD
HP HIGH PRESSURE SWITCH
LP LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
FUSE
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS
INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

3. Place the meter leads across the switch terminals of the contactor. A reading across a switch means the switch is open.

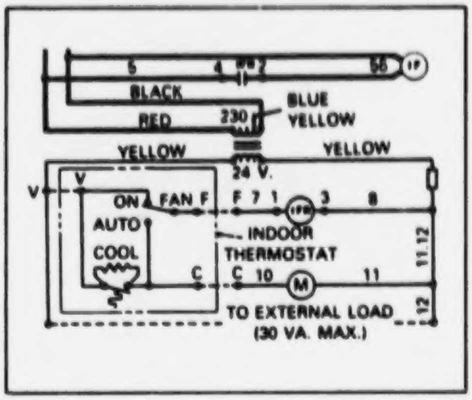
4. Why would the switch be open? What is responsible for closing the switch?

5. The coil should close the switches. The coil is 24 volt, so set the multimeter on a scale to read 24 volts. Place the meter leads on the coil terminals.


LEGEND
IF INDOOR FAN MOTOR
IFR INDOOR FAN RELAY
M CONTACTOR
OL OVERLOAD
HP HIGH PRESSURE SWITCH
LP LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
FUSE
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RUN CAP
HP
LP
RED
BLACK
BLUE
YELLOW
24 V
INDOOR THERMOSTAT
ON
AUTO
FAN
COOL
TO EXTERNAL LOAD (30 VA MAX)

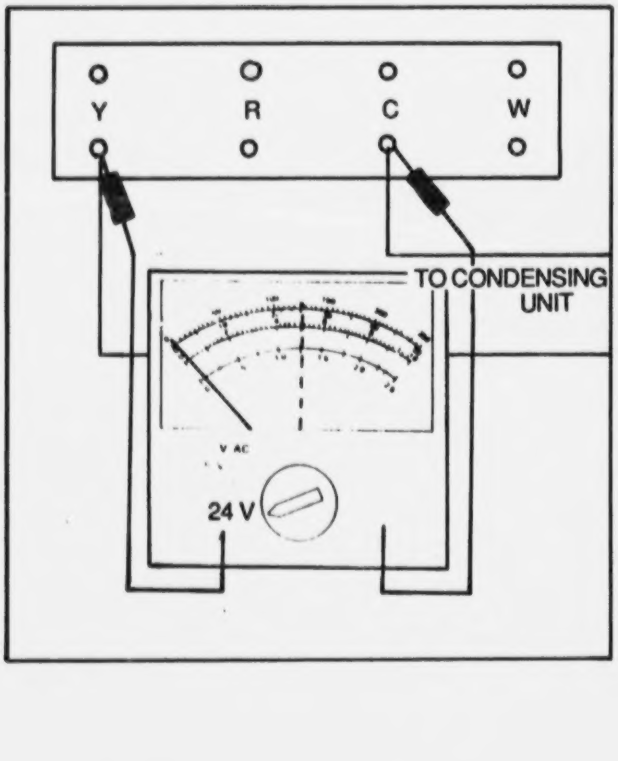
6. If you have the voltage, the coil should be energized and close the switches. Thus, the coil is open or shorted.

7. If no 24-volt control voltage is measured at the contactor coil, the problem must be in the control circuit.


5
4
2
56
IF
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V.
V
V
ON
FAN F
AUTO
COOL
C
F 7 1
IFR
3
8
INDOOR
THERMOSTAT
C 10
M
11
11.12
12
TO EXTERNAL LOAD
(30 VA. MAX.)

8. The system must have 24 volts from the furnace transformer or the furnace blower would not operate.

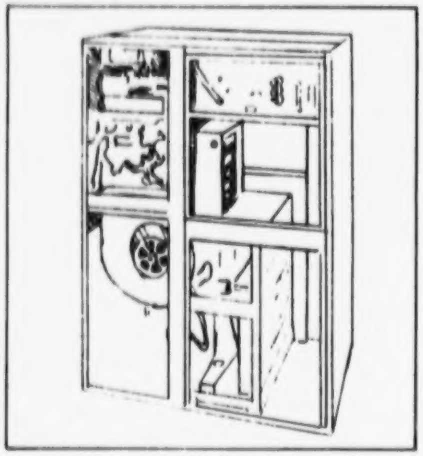
9. This only leaves the thermostat in the house. Set the thermostat on the lowest setting. Attach the multimeter lead on the wire going to the condensing unit. This should be the yellow. Place the other lead on any wire going to the secondary L2 wire on the transformer. Look at the diagram to determine which this is, or ask your instructor.

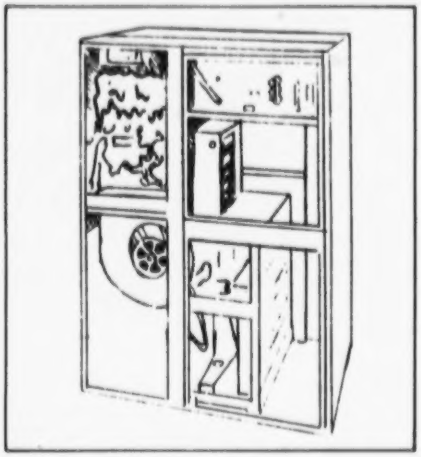

Y
R
C
W
TO CONDENSING UNIT
V AC
24 V

10. Zero voltage indicates an open in the thermostat and it should be replaced.

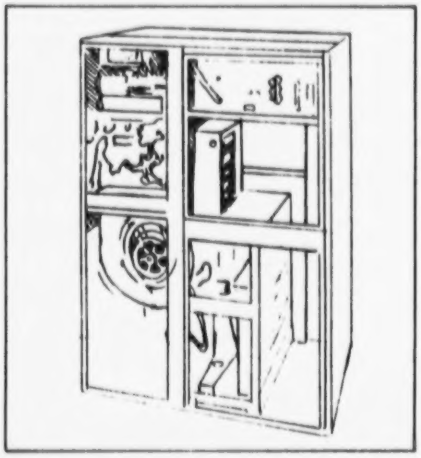
Symptom: The condensing unit operates; however, the suction line is ice covered and there is no cooling in the house.

1. Determine if the furnace blower is operating. You can do this by feeling for cool air coming out of the vents, listening for a blower noise, visually inspecting the motor.



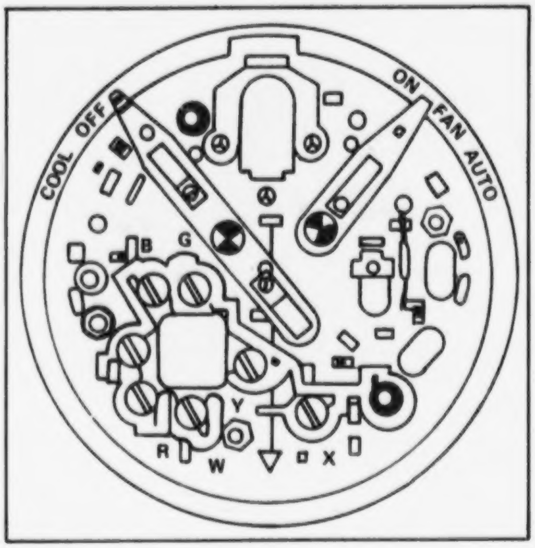


2. Improper air circulation over the evaporator will cause an iced suction line. This can result in compressor damage.



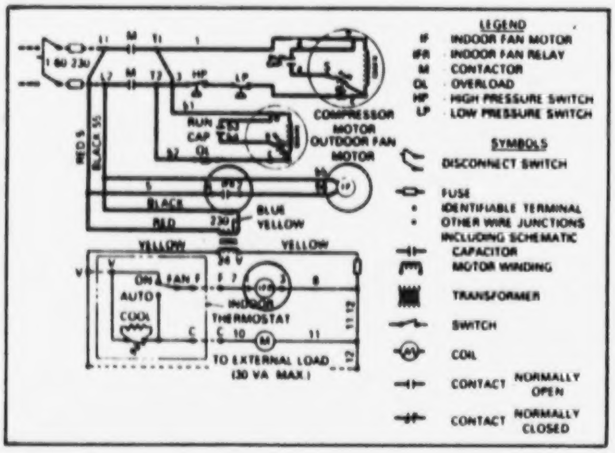
3. If the motor is not operating, turn the fan switch on the thermostat sub base to "on" or "manual" and observe. Did the motor come on?

4. If it did, the motor must be okay. Also the electrical circuit from the thermostat must be good.


COOL
OFF
ON
FAN
AUTO
B
G
R
W
Y
X

5. This only leaves the thermostat or sub base. Check the fan switch on the sub base with the multimeter set on RX1.

6. If the motor did not operate in step 3, the problem is in the motor or fan relay.


L1
M
T1
1
1 60 230
L2
M
T2
3
HP
LP
S1
RUN
CAP
S2
OL
COMPRESSOR MOTOR
OUTDOOR FAN MOTOR
RED S
BLACK 55
5
BLACK
RED
230
BLUE
YELLOW
YELLOW
YELLOW
24 V
IF
IFR
V
ON
FAN F
AUTO
COOL
C
INDOOR THERMOSTAT
10
M
11
8
TO EXTERNAL LOAD (30 VA MAX)
LEGEND
IF · INDOOR FAN MOTOR
IFR · INDOOR FAN RELAY
M · CONTACTOR
OL · OVERLOAD
HP · HIGH PRESSURE SWITCH
LP · LOW PRESSURE SWITCH
SYMBOLS
DISCONNECT SWITCH
FUSE
IDENTIFIABLE TERMINAL
OTHER WIRE JUNCTIONS INCLUDING SCHEMATIC
CAPACITOR
MOTOR WINDING
TRANSFORMER
SWITCH
COIL
CONTACT NORMALLY OPEN
CONTACT NORMALLY CLOSED

7. Check the motor for voltage. If potential is getting to the motor, it should operate; if not, check the relay.

DO SKILL SHEET 1

DO ACTIVITY SHEETS 1 AND 2

SKILL SHEET 1

Directions: The steps of procedure for a quick check of the refrigerant level in a window air conditioner are listed below. Arrange them in order.

Restrict air flow and watch the low side for frost at the level of refrigerant.

Turn the thermostat to maximum cool position.

Carefully observe the suction line for sweating and frost.

Watch for frost forming on the suction line. (This means your unit is charged properly.)

Turn the window unit on to the low cool position.

1. ____

2. ____

3. ____

4. ____

5. ____

CLEANING THE CONDENSER

ACTIVITY SHEET 1

Demonstrate the ability to clean dirt, leaves and grass clippings from the condenser of a central air conditioning system.

Check off the items as you do them:

1. Wear safety glasses.
2. Brush excess dirt, leaves and grass clippings from the unit.
3. Straighten the fins if necessary.
4. Cover the fan motor with plastic to protect the condenser from water and dust.
5. Use water or compressed air to wash out the condenser in the opposite direction of the air flow into the condenser.

INSPECTING THE FAN MOTOR

ACTIVITY SHEET 2

Demonstrate the ability to properly inspect the condenser fan motor and blade of a central air conditioning system.

Check of the items as you do them:

1. Wear safety glasses.
2. Check the fan motor for dirt and excessive dust on the stator.
3. Check the fan blade to determine if it is tight on the motor shaft and is not bent or cracked.
4. Clean the fan if it is dirty.
5. Oil the fan motor with 30 W oil, 3 to 4 drops maximum.
6. If the fan motor has excessive dirt in the stator, use the proper procedure to remove the motor from the bracket. Take apart, clean, put back together and reinstall the motor.

AIR CONDITIONING SYSTEMS

UNIT REVIEW

Directions: Answer the questions below.

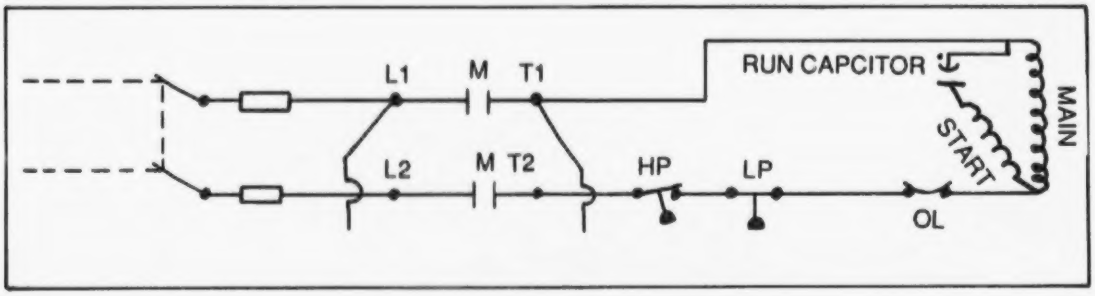
1. If a condenser fan motor has sealed bearings, the technician must apply grease as close as possible to the motor shaft that is next to the bearing.
   TRUE FALSE

2. To check the proper cycling of the thermostat, the bulb end of the thermostat should be placed in a cup of warm water.
   TRUE FALSE

3. Permanent filters may be washed and re-used.
   TRUE FALSE

4. One method of checking the proper tension of the drive belt on a motor is by checking the FLA and using an ammeter.
   TRUE FALSE

5. Dirt, leaves and grass clippings should be washed out of the condenser in the same direction they are pulled into the condenser by the fan.
   TRUE FALSE



6. In the wiring diagram at the bottom of the previous page, which switch(es) or component would keep the compressor motor from running if the contacts (M and M) were closed?

a.	HP switch	b.	LP switch
c.	OL	d.	all of the above

7. A faulty run capacitor will not keep a PSC motor from starting.

TRUE FALSE

8. Name the two different voltages found in most residential central air conditioning systems: __________ volts and ________ volts.

a.	24 and 220	b.	34 and 330
c.	9 and 442	d.	15 and 1492

9. Transformers in most residential central air conditioning systems are used to convert A.C. voltage to D.C. voltage.

TRUE FALSE

AIR CONDITIONING SYSTEMS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Perform spring checkup and troubleshoot mechanical problems on window and central air conditioning systems.			
2. Troubleshoot electrical air conditioning problems.			

Satisfactory - Should Move On ☐

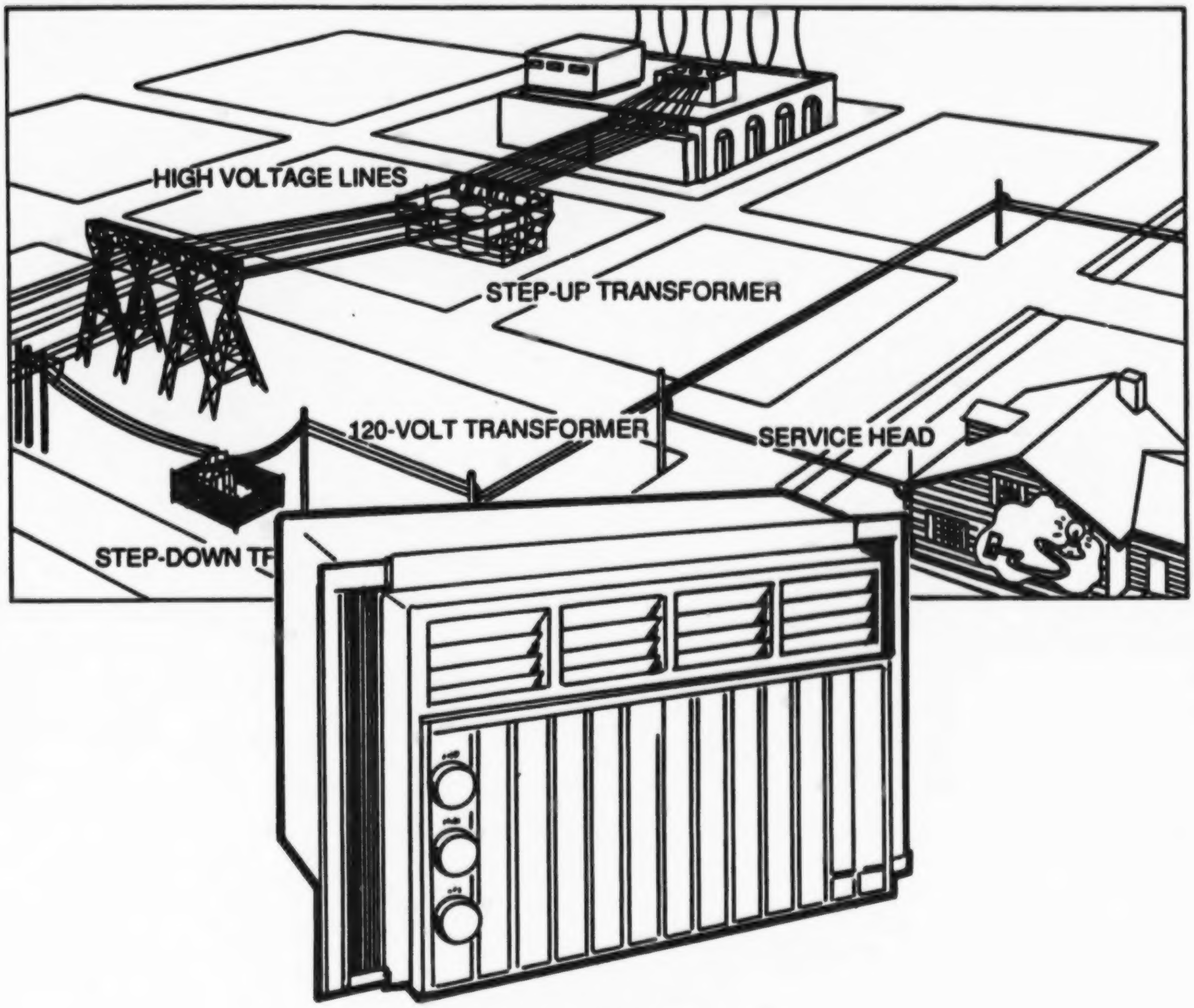
Repeat This Unit ☐

_________________________ Student's Signature/Date

_________________________ Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 10

Charging Units

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

CHARGING UNITS

INTRODUCTION

Anytime the sealed refrigeration system has been entered for repair, the system will have to be given a new charge of refrigerant. The only reason to enter the sealed refrigeration system is to repair or correct problems such as motor-compressor replacement, restrictions in the sealed system, leaks in the sealed system, an improper charge of refrigerant.

When the sealed refrigeration system is entered, the refrigerant escapes and is replaced with air. Air that gets into the system contains moisture and noncondensable gases. These must be removed from the system before the charge can be replaced.

This unit shows you how to remove the air and moisture from a system. The unit shows how to replace the refrigerant charge in household refrigerators, freezers, and window air conditioners.

Many different methods of charging air conditioning systems exist and can be used depending upon system size, type of metering device, and if you are attempting to vapor or liquid charge. Also many "rules of thumb" exist, but the best advice is to follow the manufacturer's suggested practices and guidelines found in the service manual or during a service training meeting.

UNIT OBJECTIVE

After completing this unit, you should be able to charge a refrigerator, freezer, or window air conditioner.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to specifically:

1. Evacuate a sealed refrigeration system using the triple evacuate method.
2. Charge a refrigeration system with an exact amount of refrigerant.
3. Charge a window air conditioner.
4. Charge a central air conditioner.

Check the Statement that Fits You Best

☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

☐ **I want to study the information in this unit before I do the Performance Checklist.**

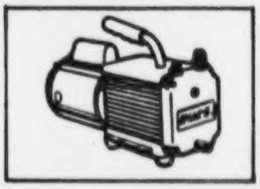
TURN PAGE AND BEGIN

A. Terms and Equipment

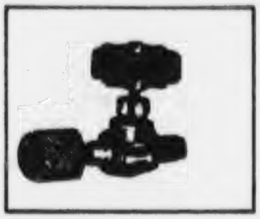
Terms

1. Charge - the exact amount of refrigerant needed for a sealed refrigeration system.
2. Charging - putting the charge into the system.
3. Evacuation - using a vacuum pump to remove air, moisture and gases from the system.
4. Refrigerant - the chemical used in the system that produces the cooling effect.
5. Purge - to blow air and noncondensable gases out of a hose or line using refrigerant.
6. High side access valve - the access valve located on the discharge line.
7. Low side access valve - the access valve located on the suction line.
8. Crack open - just barely open.

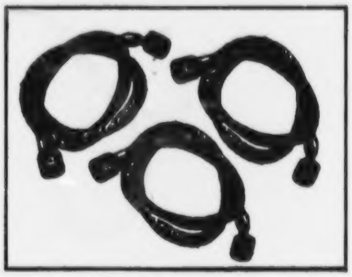
Equipment



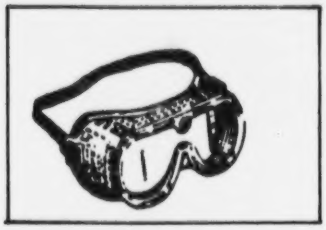
2-Stage Vacuum Pump



Charging Valve

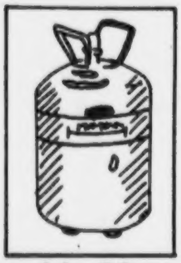


A Set of Charging Hoses



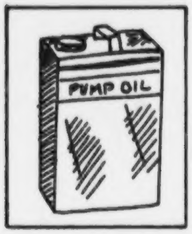
Chemical Safety Goggles

(NOTE: Safety goggles should be chemical splash-proof type.)

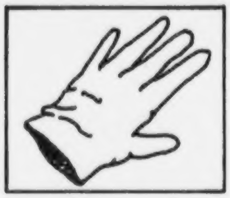


Disposable 30 or 50 Pound Container of Refrigerant

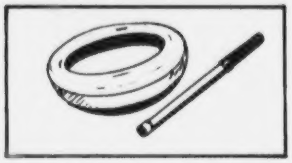
(NOTE: Refrigerant must be the same type as listed on the name plate of the refrigerator freezer or window air conditioner.)



Vacuum Pump Oil

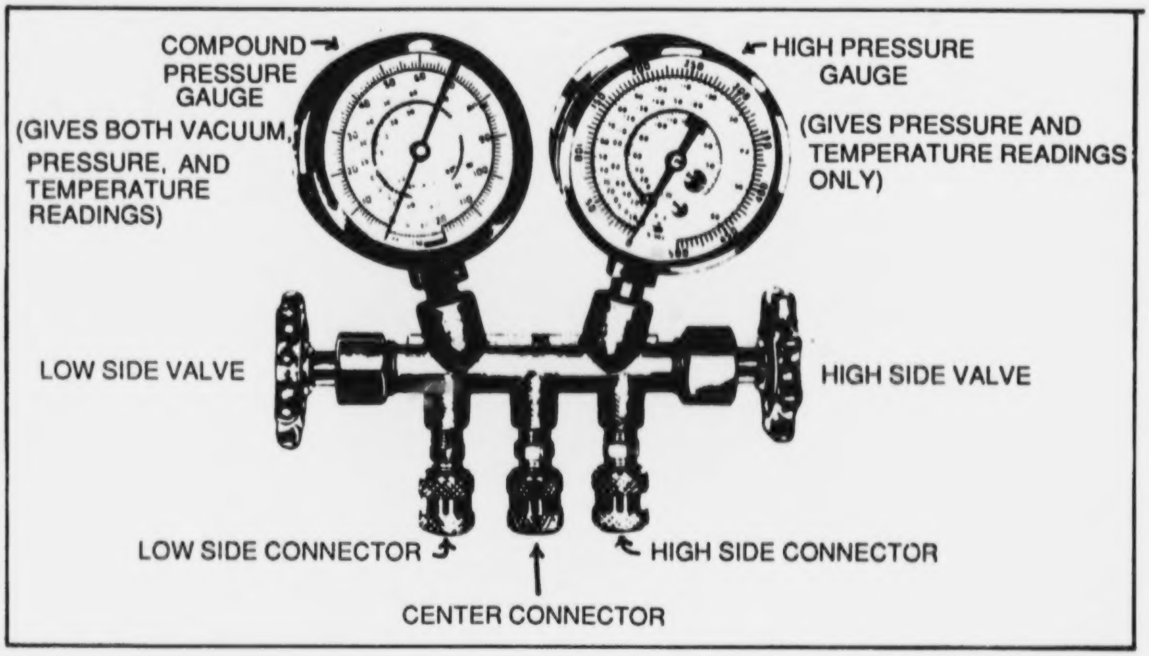


Hand Glove

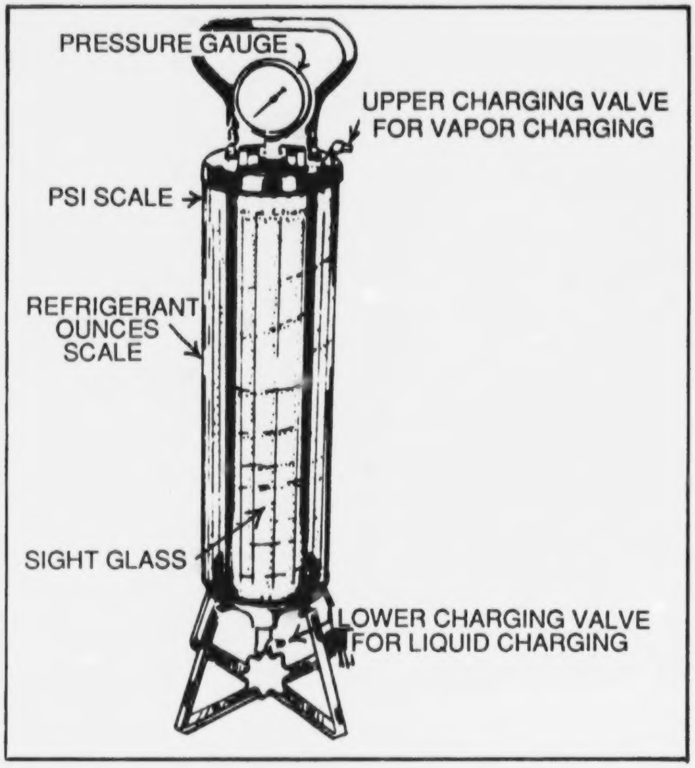


Roll of Masking Tape and Pen

Gauge Manifold Set


COMPOUND PRESSURE GAUGE
(GIVES BOTH VACUUM, PRESSURE, AND TEMPERATURE READINGS)
HIGH PRESSURE GAUGE
(GIVES PRESSURE AND TEMPERATURE READINGS ONLY)
LOW SIDE VALVE
HIGH SIDE VALVE
LOW SIDE CONNECTOR
HIGH SIDE CONNECTOR
CENTER CONNECTOR

Charging Cylinder


PRESSURE GAUGE
UPPER CHARGING VALVE FOR VAPOR CHARGING
PSI SCALE
REFRIGERANT OUNCES SCALE
SIGHT GLASS
LOWER CHARGING VALVE FOR LIQUID CHARGING

B. Procedures Before Evacuating and Charging a System

Before beginning the steps of procedure for evacuating and charging a system, check to make sure the following have been completed.

_____1. All repairs to the system have been completed.

_____2. If the system contained a filter-dryer, the filter dryer has been replaced.

_____3. Valve core type access valves have been installed on the suction and discharge lines.

_____4. The system has been tested for leaks and there are no leaks.

_____5. You have learned how to use all tools listed in the Equipment section.

_____6. The system has no pressure in it.

C. Steps of Procedure for Evacuating a System

The system should always be evacuated before charging. The method of evacuation shown in this unit is called the triple evacuation method.

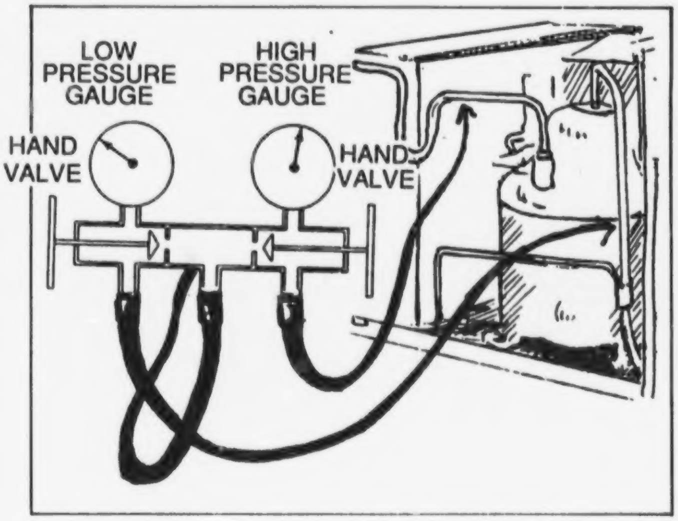
CAUTION

1. **Always check the oil lever on the vacuum pump before using it.**
2. **Always change the oil in a vacuum pump with fresh oil after using it.**
3. **Never connect a vacuum pump to a system that is under pressure.**

1. Connect the hoses and gauge manifold as shown in the illustration of a gauge manifold set in the Equipment section.

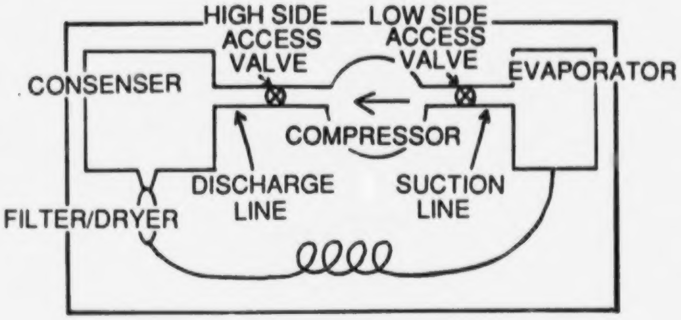
   Connect a charging valve to the end of the red (high side) hose as shown here.

   Be sure the end of the hose with the built-in valve depressor is away from the manifold.

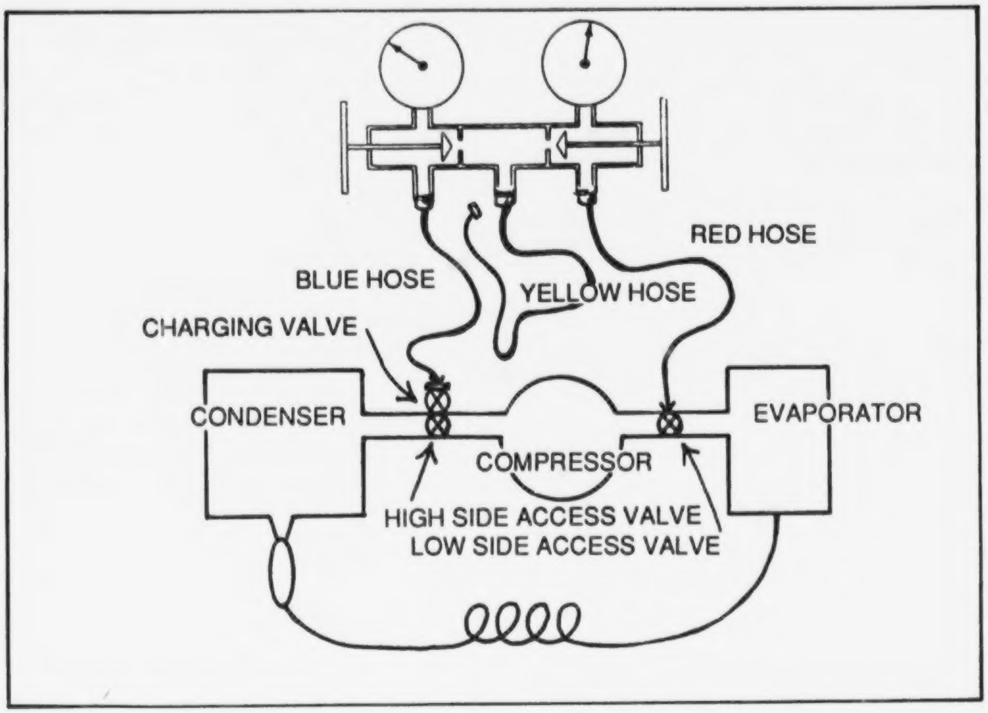


2. Remove the caps from the access valves on the suction and discharge lines.

   Inspect the refrigeration system and identify all parts shown here. This illustration shows a refrigeration system with access valves installed on suction and discharge lines.


HIGH SIDE ACCESS VALVE
LOW SIDE ACCESS VALVE
CONSENSER
EVAPORATOR
COMPRESSOR
DISCHARGE LINE
SUCTION LINE
FILTER/DRYER

Connect the gauge manifold to the refrigerant system as shown below.

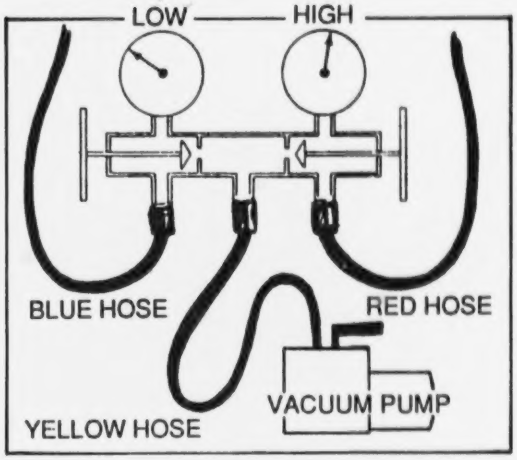

RED HOSE
BLUE HOSE
YELLOW HOSE
CHARGING VALVE
CONDENSER
EVAPORATOR
COMPRESSOR
HIGH SIDE ACCESS VALVE
LOW SIDE ACCESS VALVE

4. Open the charging valve and both manifold valves. Check that the system has no pressure.

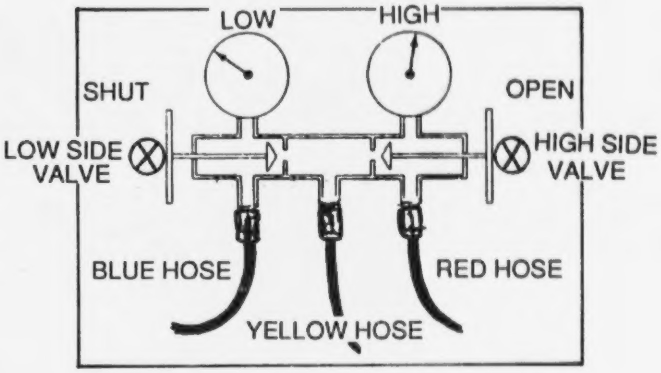
5. Check the oil level 1/2 way up the sight glass on the vacuum pump.

6. Start the vacuum pump.

7. Connect the yellow center hose from the gauge manifold to the vacuum pump.

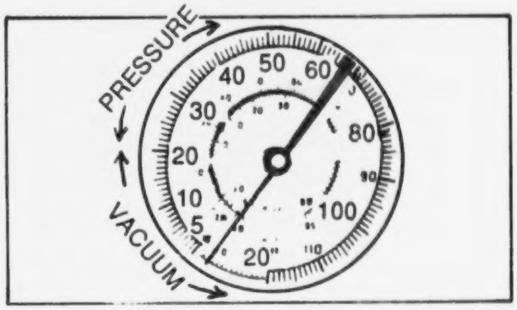

LOW
HIGH
BLUE HOSE
RED HOSE
VACUUM PUMP
YELLOW HOSE

8. Shut the low side gauge manifold valve and open the high side gauge manifold valve.

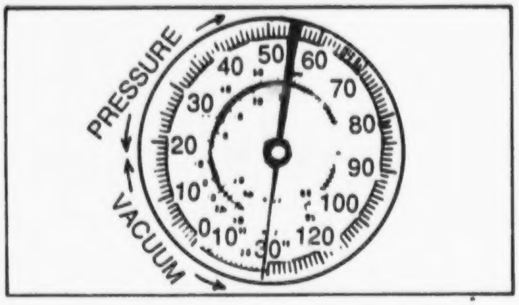

LOW
HIGH
SHUT
OPEN
LOW SIDE VALVE
HIGH SIDE VALVE
BLUE HOSE
RED HOSE
YELLOW HOSE

9. When the low side gauge (compound gauge) reads 5 inches of vacuum, open the low side manifold valve.

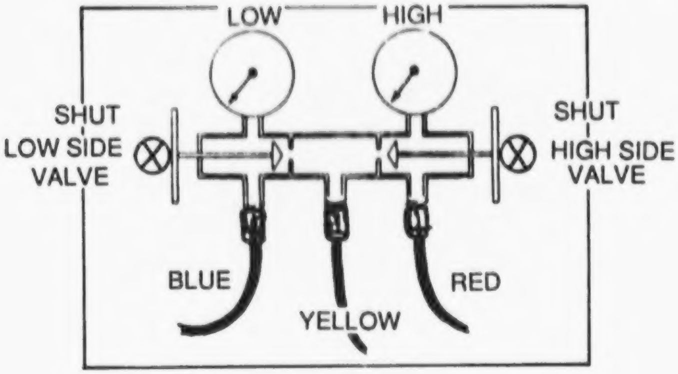
   Continue running the vacuum pump.


PRESSURE
VACUUM
40
50
60
30
80
20
10
5
100
20"

10. Run the vacuum pump for 20 minutes after the compound gauge reads 29 inches of vacuum.


PRESSURE
VACUUM
0
10
20
30
40
50
60
70
80
90
100
120
10"
30"

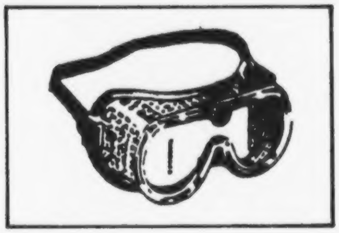
11. Shut high and low side manifold valves.


LOW
HIGH
SHUT
LOW SIDE
VALVE
SHUT
HIGH SIDE
VALVE
BLUE
YELLOW
RED

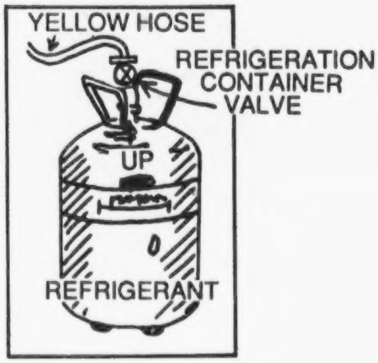
12. Turn off the vacuum pump.

13. Disconnect the yellow center hose from the vacuum pump.

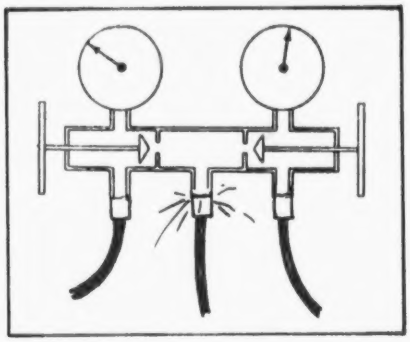
14. **CAUTION: Put on your splash-proof chemical safety goggles.**



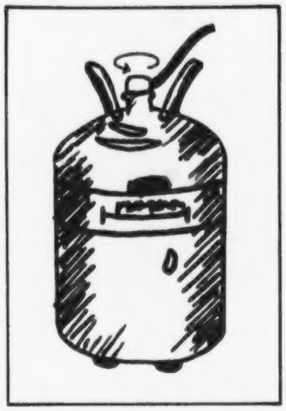
15. Connect the yellow center hose to the container of refrigerant. Be sure the container remains right side up with valve at top of the container.


YELLOW HOSE
REFRIGERATION CONTAINER VALVE
UP
REFRIGERANT

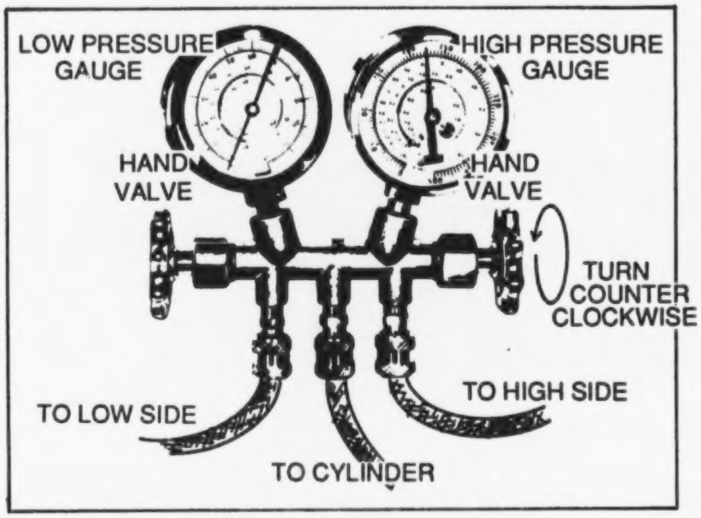
16. Purge the center hose:
    a. Loosen hose connection to manifold.
    b. Crack open valve on refrigerant container.
    c. When refrigerant gas blows out hose at manifold, tighten hose connection.



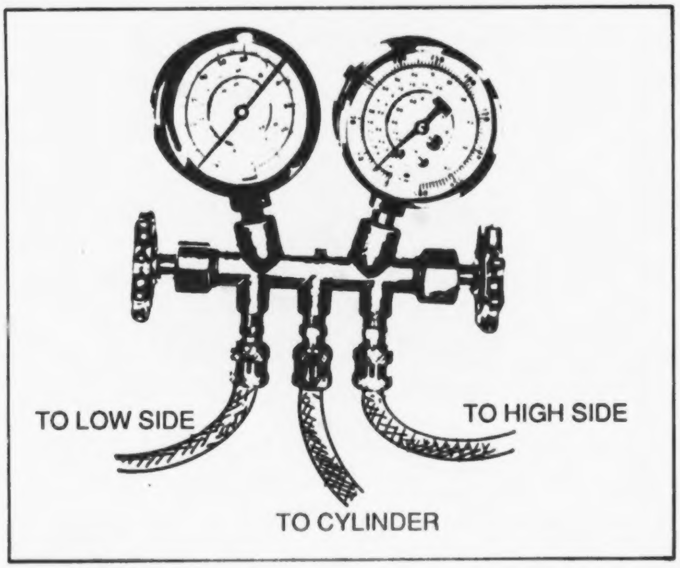
17. Open the refrigerant container valve by turning the valve counter clockwise.

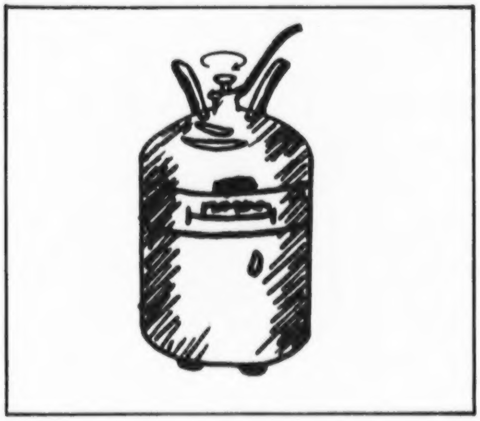


18. Open the high side manifold valve.


LOW PRESSURE GAUGE
HIGH PRESSURE GAUGE
HAND VALVE
HAND VALVE
TURN COUNTER CLOCKWISE
TO LOW SIDE
TO HIGH SIDE
TO CYLINDER

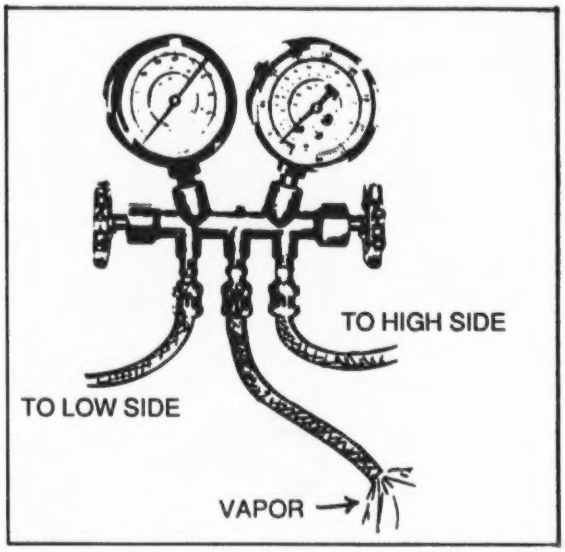
19. Pressurize the system to 5 PSI as read on both gauges.


TO LOW SIDE
TO HIGH SIDE
TO CYLINDER



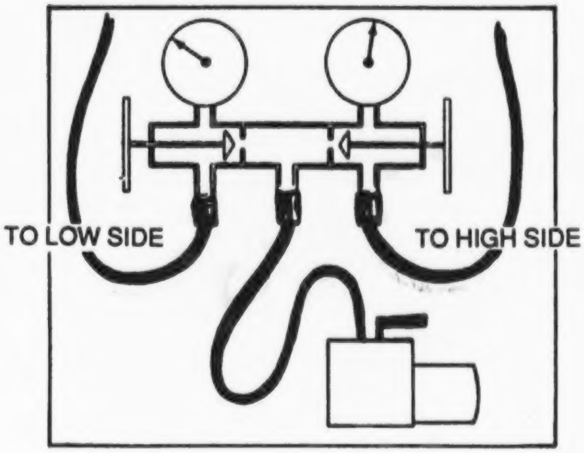
20. Shut the refrigerant container valve.

21. WAIT FOR 5 MINUTES.


TO HIGH SIDE
TO LOW SIDE
VAPOR

22. Disconnect the yellow hose from the container and allow the refrigerant to escape from system and depressurize.

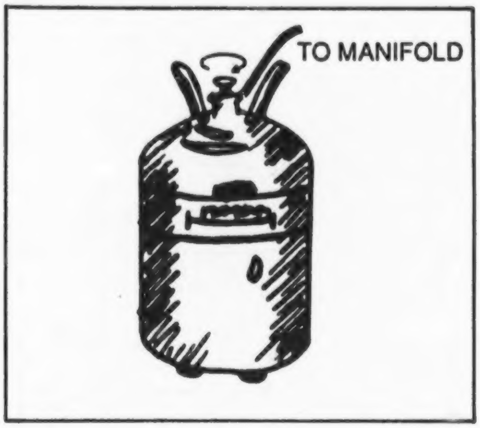
23. Connect the yellow hose to the vacuum pump.


TO LOW SIDE
TO HIGH SIDE

24. Repeat steps 7 through 23 one more time.

25. Repeat steps 7 through 12.

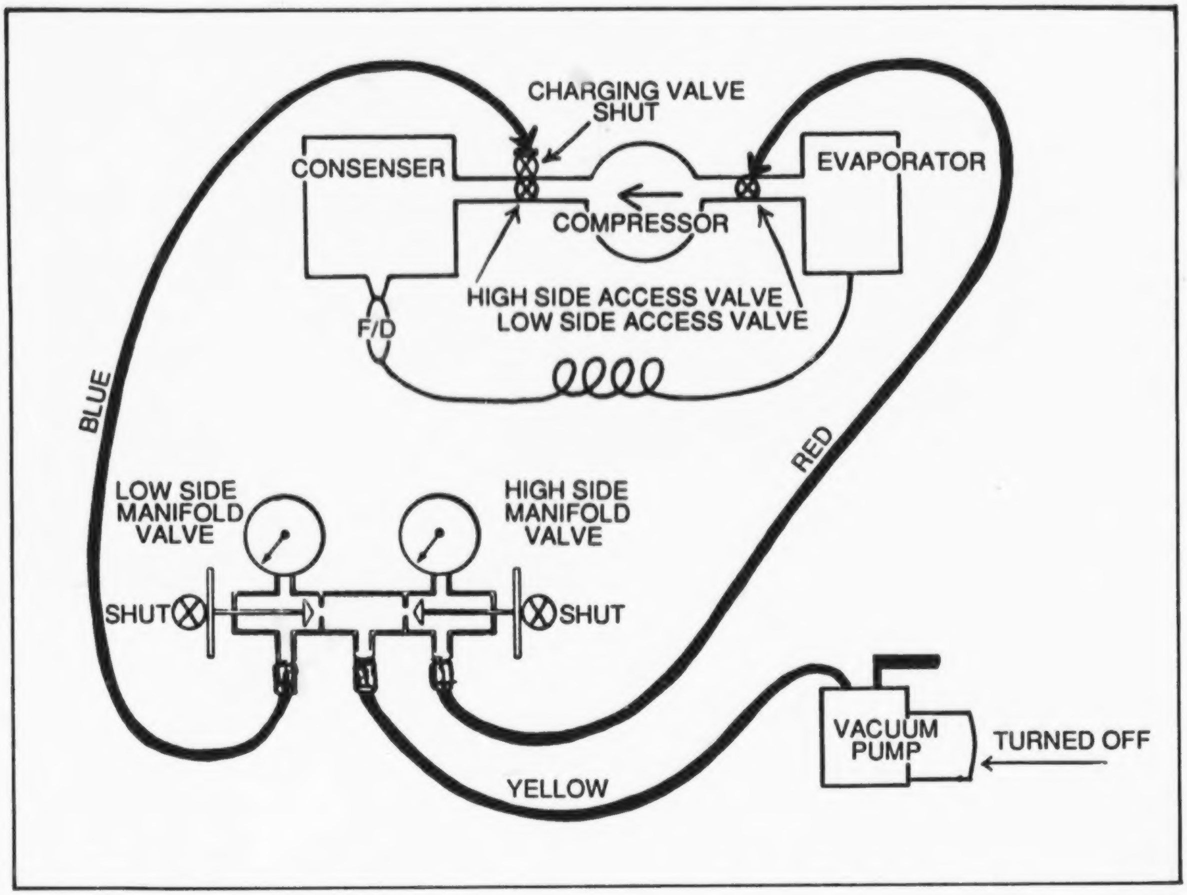
26. Shut the charging valve.


TO MANIFOLD

STOP

The system has been triple evacuated. You are now ready to start charging! The status of the system at this time should be as shown on the next page.

This is how the system and manifold should be at the end of the triple evacuation.


CHARGING VALVE
SHUT
CONSENSER
EVAPORATOR
COMPRESSOR
F/D
HIGH SIDE ACCESS VALVE
LOW SIDE ACCESS VALVE
BLUE
RED
LOW SIDE MANIFOLD VALVE
HIGH SIDE MANIFOLD VALVE
SHUT
SHUT
VACUUM PUMP
TURNED OFF
YELLOW

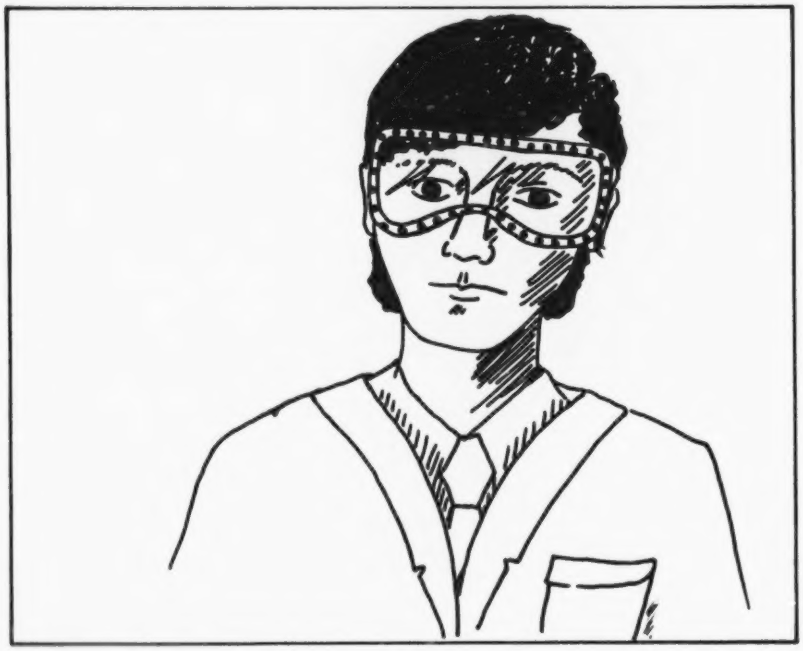
1. All three hand valves are shut.
2. Vacuum pump is turned off.
3. Low side (compound) gauge reads 29 or 30 inches of vacuum.
4. High side gauge reads less than 0 PSI.

D. Steps of Procedure for Charging a System

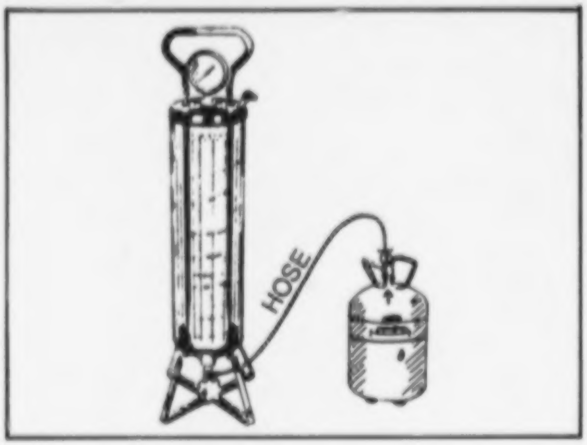
After the system has been evacuated, the charging procedure can be started. To charge a system, you must know what type of refrigerant the system uses and how much refrigerant is needed. This information can be found on the equipment name plate.

> **CAUTION: ALWAYS WEAR THE SPLASH PROOF CHEMICAL TYPE SAFETY GOGGLES WHEN WORKING WITH REFRIGERANT. THESE GOGGLES MUST BE WORN DURING THE ENTIRE CHARGING PROCEDURE.**

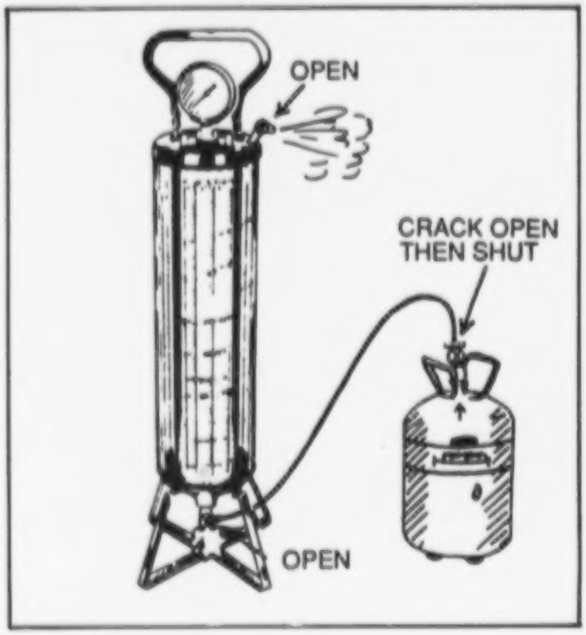
1. Put on your chemical safety goggles



2. Select an empty charging cylinder. Connect a charging hose from the lower charging valve to the valve on the container of refrigerant. Be sure the refrigerant container is in the upright position.



3. Open the upper and lower charging valves on the charging cylinder. Let all pressure bleed off the charging cylinder.



4. Crack open the valve on the refrigerant container and purge the hose and cylinder with refrigerant gas.

5. When refrigerant gas flows from the upper charging valve for two seconds, shut the refrigerant container valve.

6. Shut the upper charging valve on the charging cylinder when cylinder gauge reads from 1 to 2 lbs. of pressure.

7. Adjust the charging cylinder so the refrigerant ounce scale is set for the type of refrigerant being used.

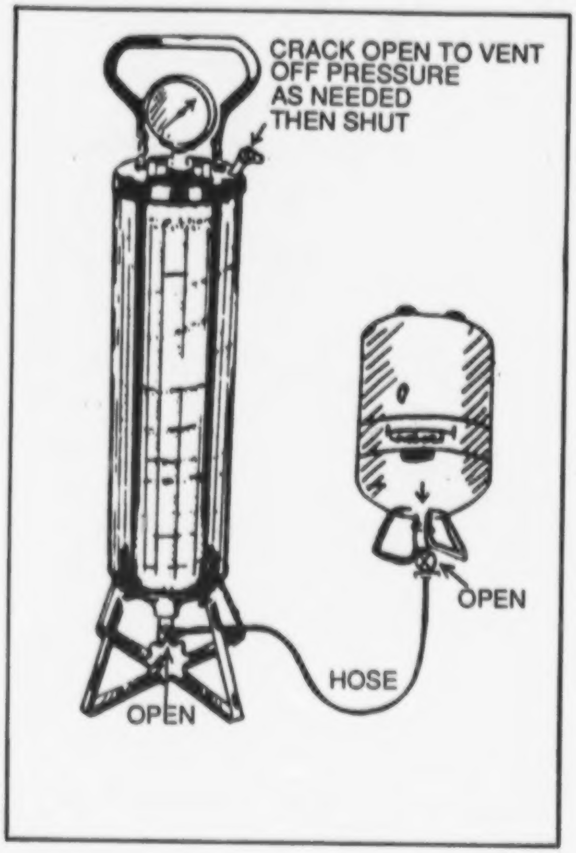
8. Transfer refrigerant from the refrigerant container to the charging cylinder as follows.

a. Set the refrigerant container upside down.

b. Open the valve on the refrigerant container, open the lower charging valve on the charging cylinder. Refrigerant will flow from the container to the charging cylinder.

c. It may be necessary to crack open the upper charging valve to reduce pressure for a few seconds at a time.

d. When the sight glass shows 6 ounces more than the system being charged needs, shut the lower charging valve.



You now have 6 more ounces of refrigerant than you need trapped inside the charging cylinder.

9. Drain the liquid refrigerant from the hose back into the refrigerant container.

a. Place the refrigerant container in the upright position.

b. Place the refrigerant container lower than the charging cylinder.

c. With both charging cylinder valves shut and the container valve open, rub the hose with your hands from top to bottom.

Rub the hose for one minute.

d. Shut the refrigerant container valve.

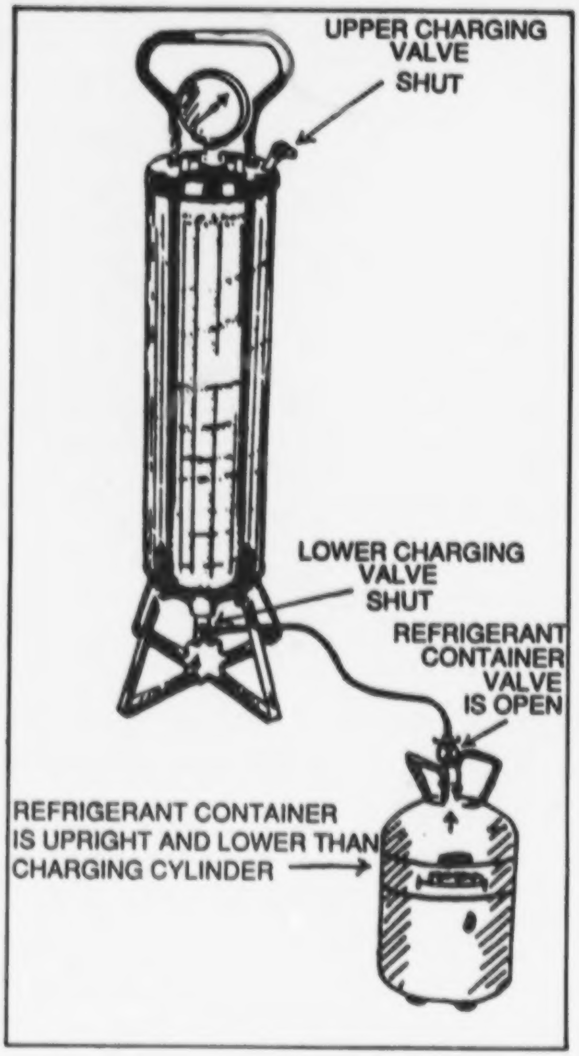
CAUTION: USE A GLOVE ON YOUR HAND FOR THE NEXT STEP. YOU SHOULD HAVE YOUR GOGGLES ON.

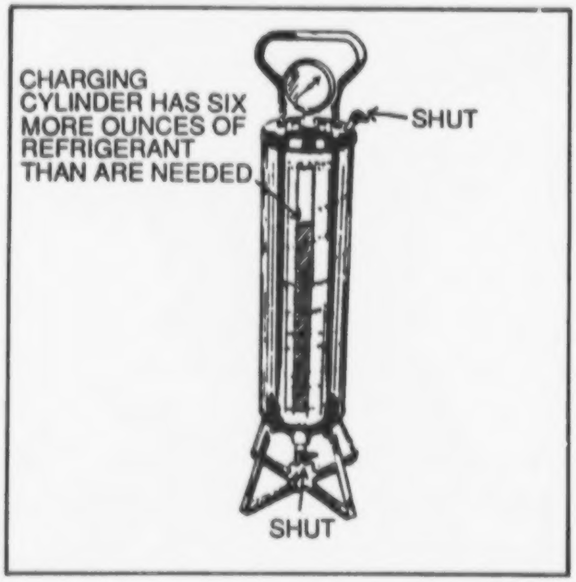
e. Check all valves shut, then remove the hose from the refrigerant container.

f. Remove the hose from the charging cylinder.

Now you can remove the glove from your hand.

10. Put the refrigerant container back in its storage place.


UPPER CHARGING VALVE SHUT
LOWER CHARGING VALVE SHUT
REFRIGERANT CONTAINER VALVE IS OPEN
REFRIGERANT CONTAINER IS UPRIGHT AND LOWER THAN CHARGING CYLINDER


CHARGING CYLINDER HAS SIX MORE OUNCES OF REFRIGERANT THAN ARE NEEDED
SHUT
SHUT

At this time the refrigerant system should be connected to the gauge manifold and charging valve as shown on page 19. The charging valve should be shut. The high and low side manifold valves should be shut. The compound gauge should read 29 or 30 inches of vacuum. The vacuum pump should be connected to the center hose and turned off. The charging cylinder should be as shown in the illustration at the bottom of page 24.

11. Disconnect the vacuum pump from the yellow center hose on the manifold.

12. Connect the yellow center hose on the manifold to the lower charging valve on the charging cylinder.

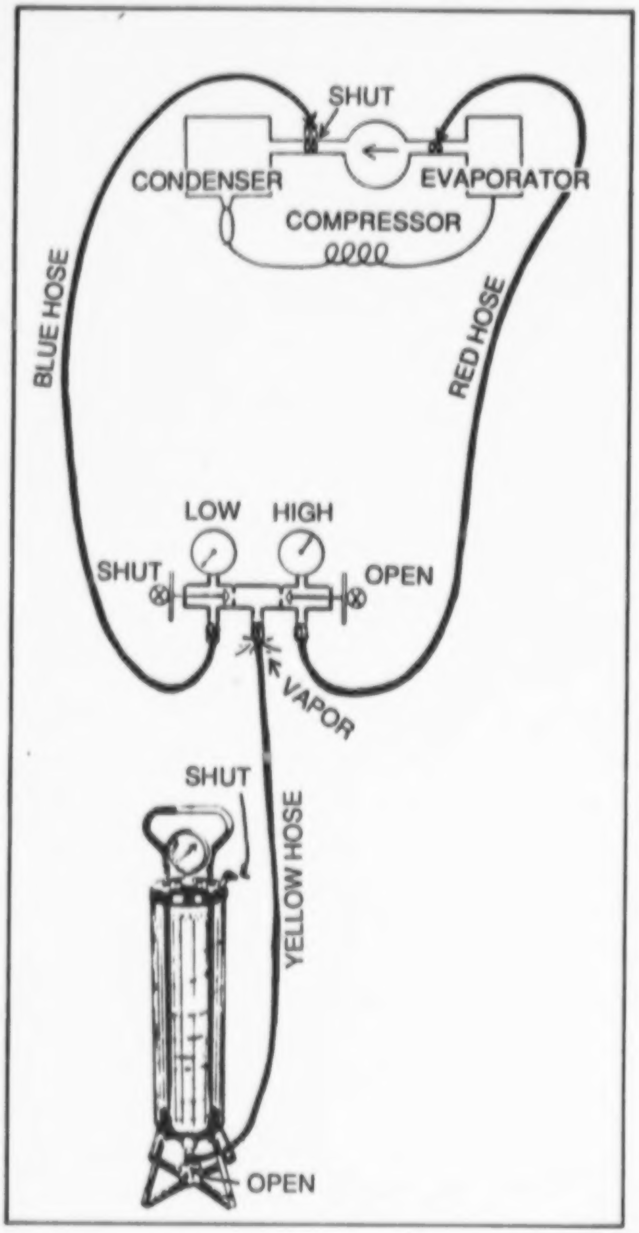
13. Open the lower charging valve on the cylinder.

14. Purge service hose.

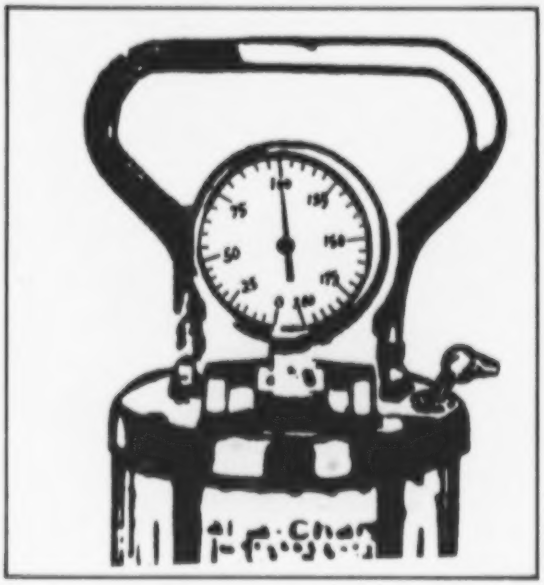
15. Open the high side gauge manifold valve.

CAUTION: PUT A GLOVE ON YOUR HAND FOR THE NEXT STEP. BE SURE YOUR GOGGLES ARE ON!

16. Loosen the connection from the red hose to the charging valve until liquid refrigerant comes out the connection. Then tighten the connection.



17. Read the pressure gauge on top of the charging cylinder and check ounce scale set for type of refrigerant. Adjust ounce scale over sight glass for correct pressure column.



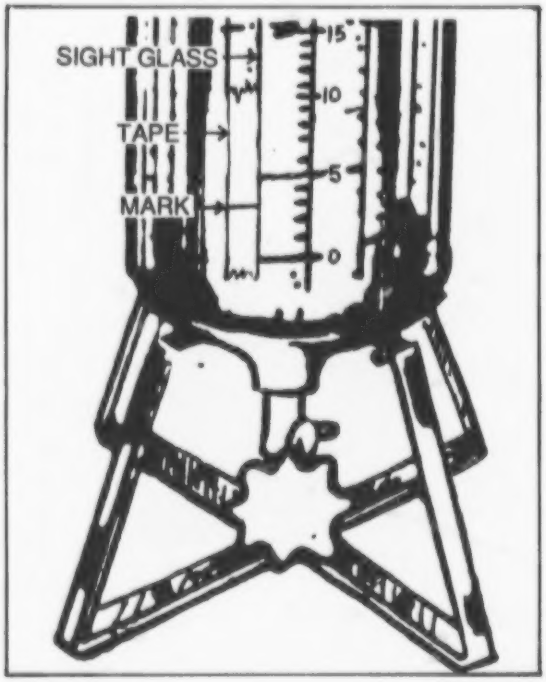
18. Record the number of ounces in the sight glass.

    Subtract the amount of refrigerant needed for the system.

    The number left after subtracting is the amount of refrigerant that will be left in the charging cylinder. An example is shown here.

24 ← OUNCES IN SIGHT GLASS
-21 ← OUNCES NEEDED
3 ← OUNCES LEFT AFTER CHARGING

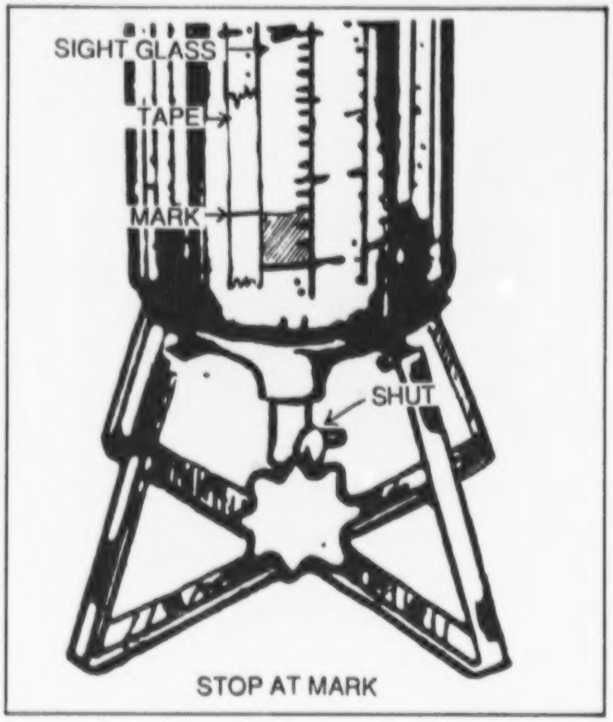
19. Use a piece of tape to mark the sight glass with this number.



20. Open the charging valve.

    Refrigerant will flow from the charging cylinder to the system.

21. When the refrigerant in the sight glass is even with the mark on the tape, **SHUT THE CHARGING VALVE** and shut the lower charging valve on the charging cylinder.

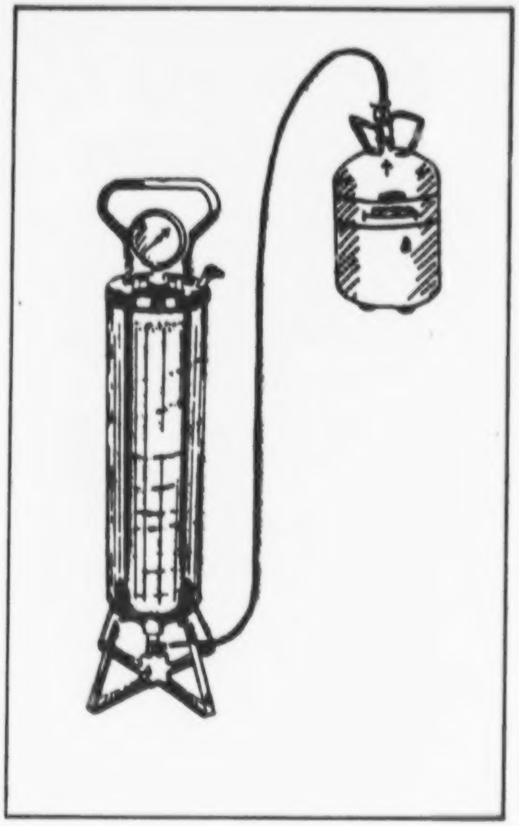


NOTE: Sometimes all of the needed charge will not go into the system before the pressures equalize. If this happens, record the number of ounces of refrigerant above the mark. This remaining charge will be added to the system as a vapor later in the procedure. Shut the charging valve and the lower charging valve on the cylinder.

Number of ounces of refrigerant above the mark = 3 ounces.

At this time, liquid refrigerant is trapped in the red and yellow hoses and must be forced back into the charging cylinder.

22. Place the charging cylinder at the lowest level possible and open the lower charging valve.
23. Starting at the charging valve, rub the red hose from the charging valve working toward the manifold. Rub the hose for at least one minute.
24. Shut the high side gauge manifold valve.



25. Rub the yellow hose starting from the manifold and working toward the charging cylinder. Rub the hose for at least one minute.
26. Shut the lower cylinder charging valve.
27. At this time, **ALL** valves should be shut.

High side gauge Manifold valve = SHUT

Low side gauge Manifold valve = SHUT

Upper charging cylinder valve = SHUT

Lower charging cylinder valve = SHUT

Charging valve = SHUT

Check all valves SHUT

CAUTION: PUT A GLOVE ON YOUR HAND FOR THE NEXT STEPS OF THE PROCEDURE. BE SURE YOUR SAFETY GOGGLES ARE ON.

28. Disconnect the red hose from the charging valve and attach to hose keeper on the manifold back.

29. Disconnect the yellow hose from the charging cylinder and attach to the hose keeper on the manifold back.

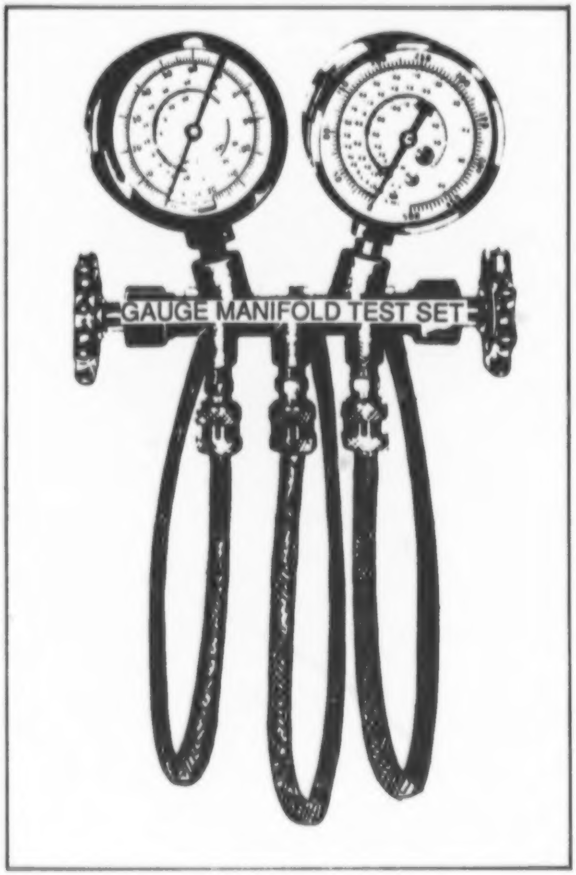
30. Quickly disconnect the blue hose from the low side access valve and attach to the hose keeper on the manifold back.

31. Quickly remove the charging valve.

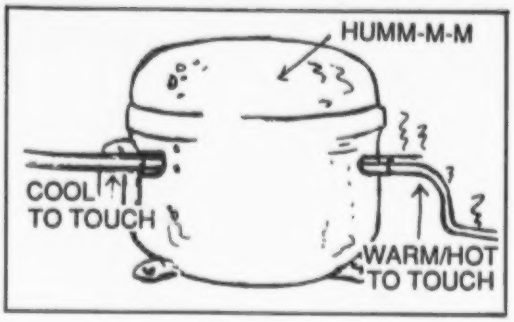
    You may remove your glove at this time.

32. Place caps on access valves and check them for leaks.

33. Plug the unit into a power supply and start the unit. Observe to determine that the system is running properly.



34. With the compressor running, feel for heat at the discharge line.

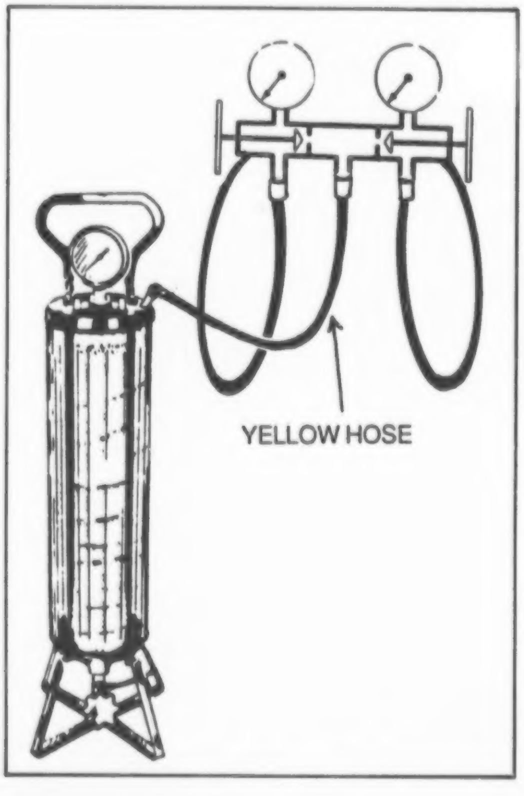


35. If all the refrigerant needed for a full charge went into the system in step 21, the charging of the system is completed. Go on to step 46.

If only part of the refrigerant was charged before pressures equalized in step 21, the remainder of the charge must be charged as a vapor.

Charging Refrigerant As a Vapor

36. Connect the yellow hose from the center connection on the manifold to the upper valve on the charging cylinder. Check all valves shut.

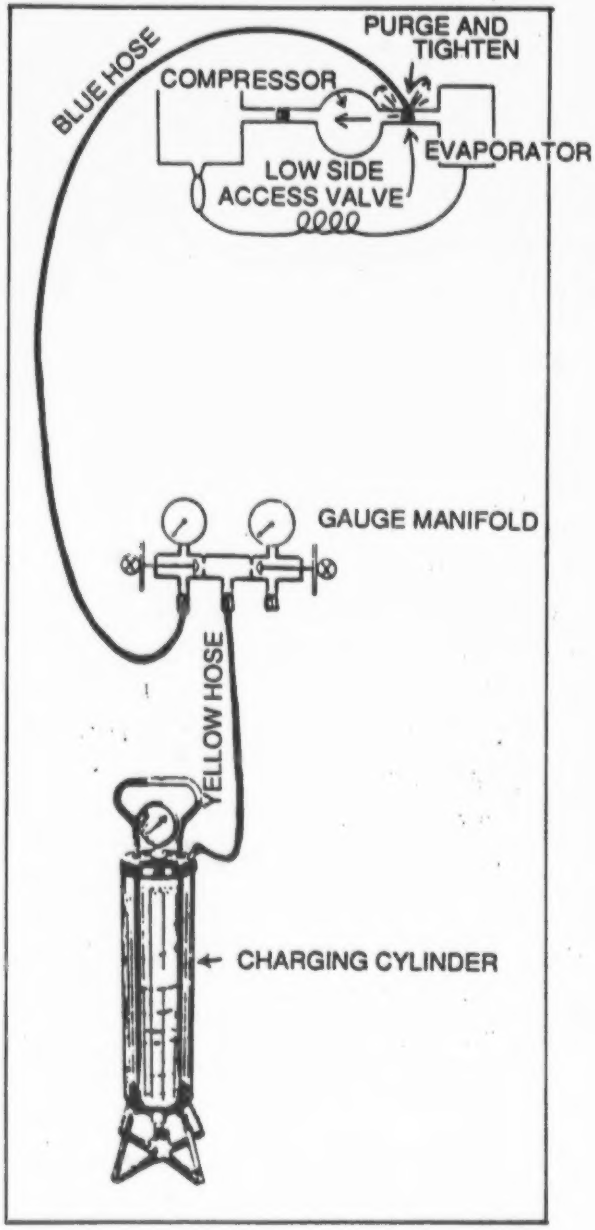


37. Open the upper charging cylinder valve.

    Crack open the low side manifold valve.

    Purge refrigerant out of the blue hose and connect blue hose to low side access valve.

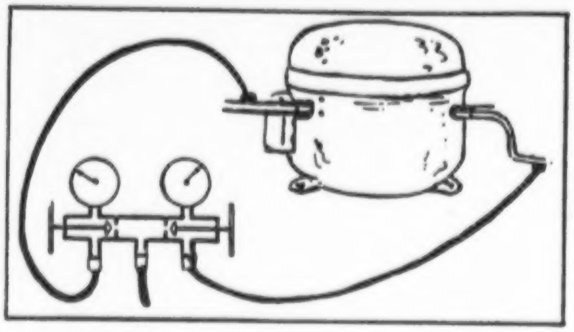
    Shut low side manifold valve.


BLUE HOSE
PURGE AND TIGHTEN
COMPRESSOR
EVAPORATOR
LOW SIDE ACCESS VALVE
GAUGE MANIFOLD
YELLOW HOSE
CHARGING CYLINDER

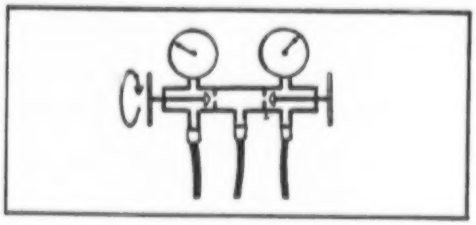
38. Line up refrigerant scales for type of refrigerant and pressure.

39. Subtract the number of ounces recorded in step 21 from the amount remaining in the charging cylinder. Mark this number with tape on the sight glass.

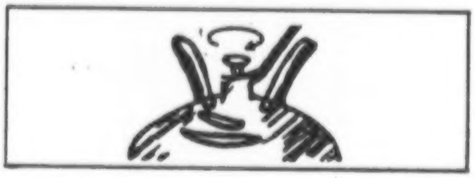
40. With the compressor running, operate the low side manifold valve as needed until the refrigerant in the cylinder is equal with the mark made in step 39 earlier.



41. Shut the low side manifold valve.



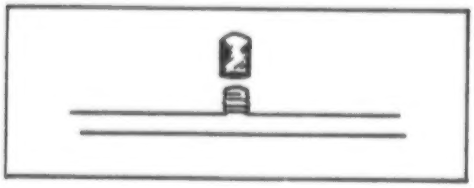
42. Shut the charging cylinder valve.



43. Run system to check temperature and pressure on both high and low side. You can also use an ammeter to see if the unit is pulling FLA.

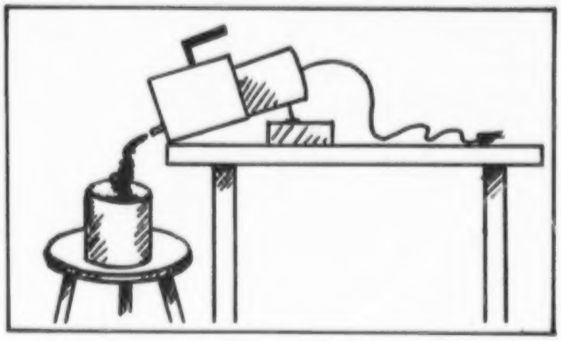
44. Remove all hoses and make up to keepers on back of the manifold.

45. Place caps on access valves and check them for leaks.



This completes the charging procedure. Go to step 46.

46. Change oil in the vacuum pump.



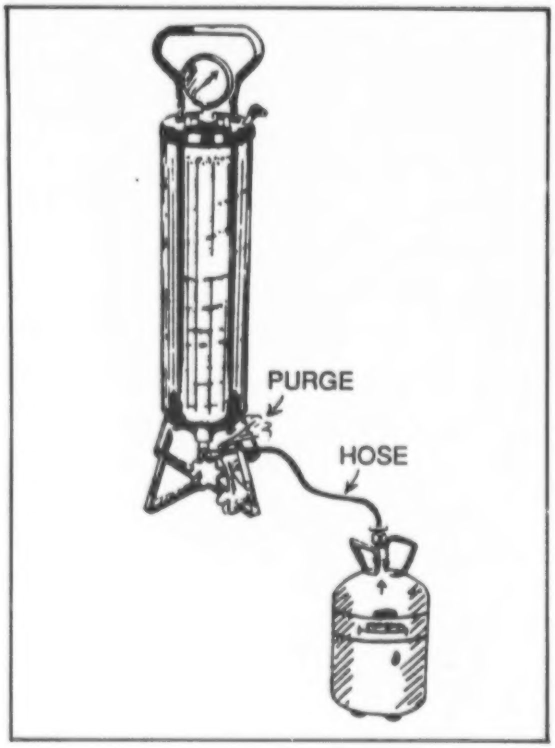
47. Transfer any refrigerant left in the charging cylinder back to the refrigerant's original container as follows:

    a. Connect a hose from the lower charging cylinder valve to the valve on top of the refrigerant container.

    b. Place the refrigerant container in an upright position. It should be lower than the charging cylinder.

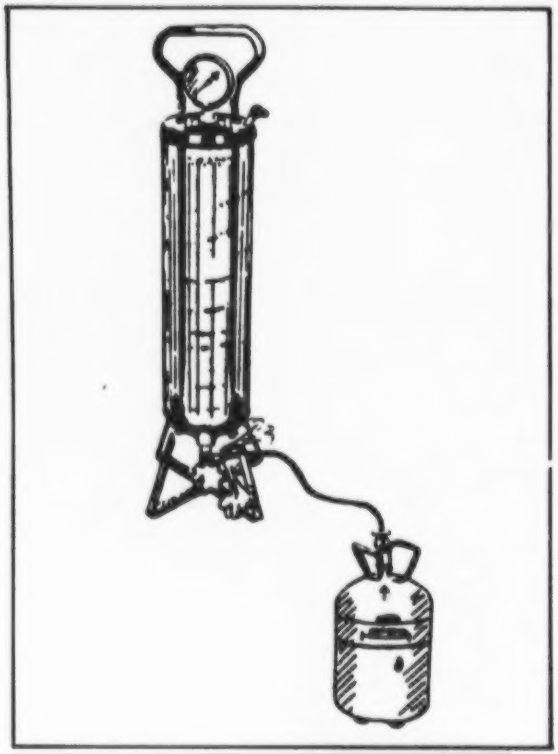
    c. Open the refrigerant container valve.

    d. Loosen the connection at the charging cylinder; purge, then tighten the hose.



e. Open the lower charging cylinder valve.

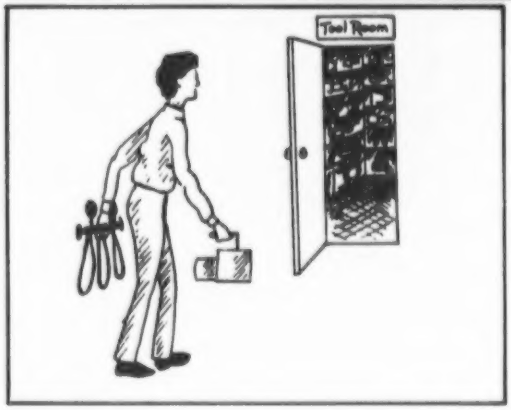
f. Rub the hose from the charging cylinder to the container until all refrigerant is out of the sight glass.



g. Continue to rub hose for one minute. Then shut **ALL** valves.

h. Disconnect the hose from the charging cylinder and container.

48. You may remove your chemical safety goggles now.



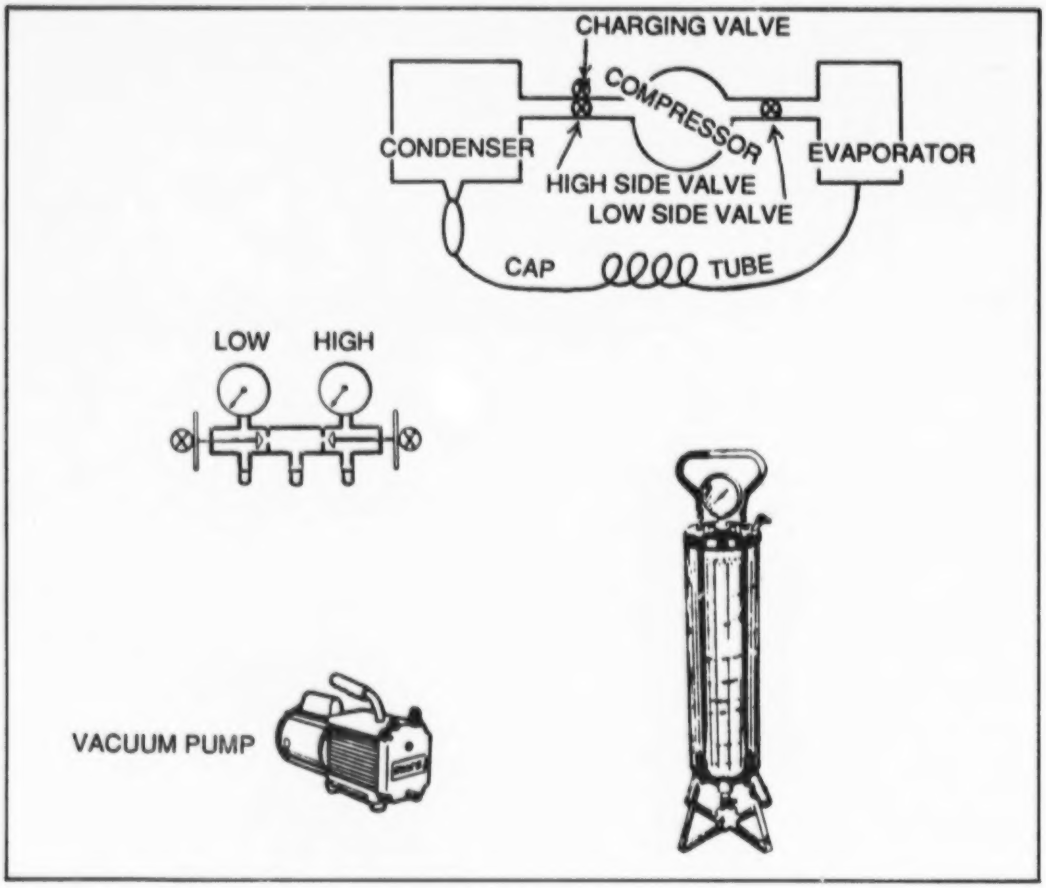
49. Put away all tools and clear your work station.

Do Activity Sheets 1, 2 and 3.

CHARGING UNITS

ACTIVITY SHEET 1

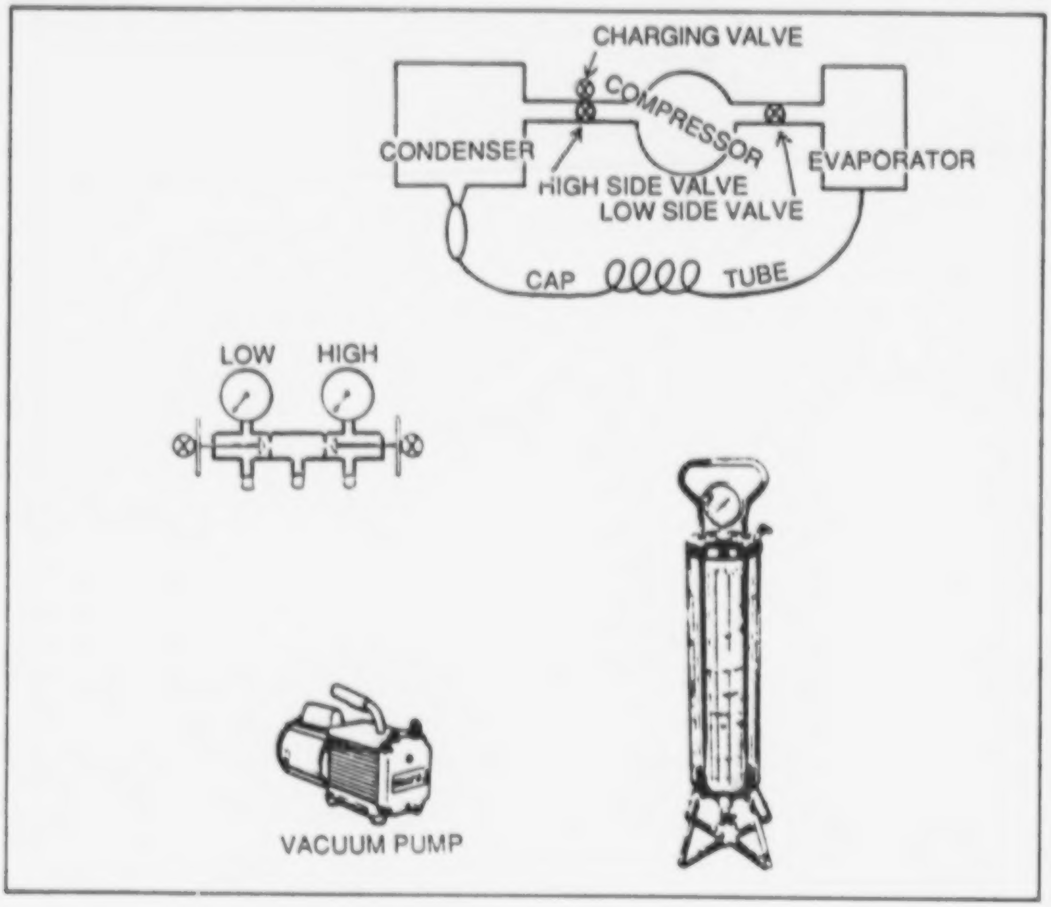
Directions: Draw hoses and show connections for system evacuation.


CHARGING VALVE
COMPRESSOR
CONDENSER
HIGH SIDE VALVE
LOW SIDE VALVE
EVAPORATOR
CAP
TUBE
LOW
HIGH
VACUUM PUMP

CHARGING UNITS

ACTIVITY SHEET 2

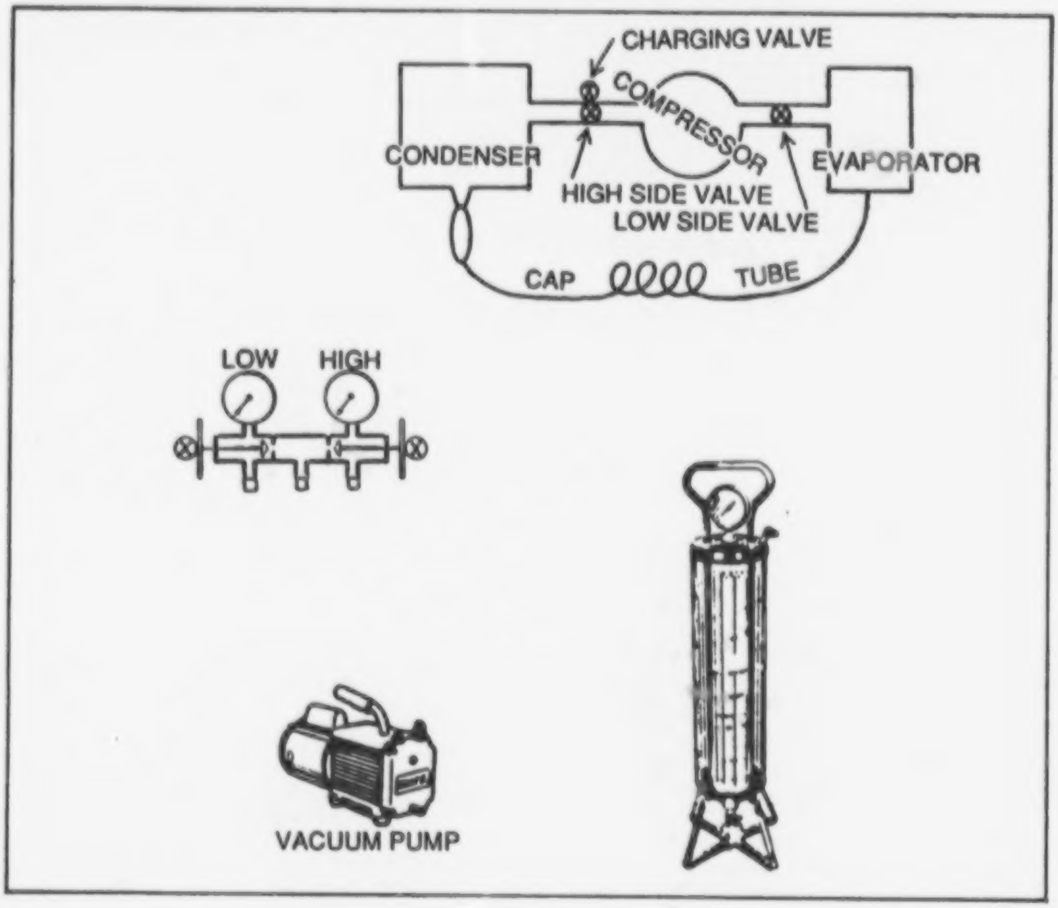
Directions: Draw hoses and show connections for charging liquid refrigerant.


CHARGING VALVE
COMPRESSOR
CONDENSER
HIGH SIDE VALVE
LOW SIDE VALVE
EVAPORATOR
CAP TUBE
LOW
HIGH
VACUUM PUMP

CHARGING UNITS

ACTIVITY SHEET 3

Directions: Draw hoses and show connections for vapor charge.


CHARGING VALVE
COMPRESSOR
CONDENSER
EVAPORATOR
HIGH SIDE VALVE
LOW SIDE VALVE
CAP TUBE
LOW
HIGH
VACUUM PUMP

E. Steps of Procedure for Charging a Window Air Conditioner -- Frost Line Method

Most window air conditioners use a capillary tube metering device with some using a TEV. For both, the charge is critical because of the system size. It is assumed that the system is being charged because of a loss of refrigerant charge due to a repair, rather than initial start-up and balance of a system. (NOTE: Some new charging equipment is available that will change techniques that are used, but these are not covered.)

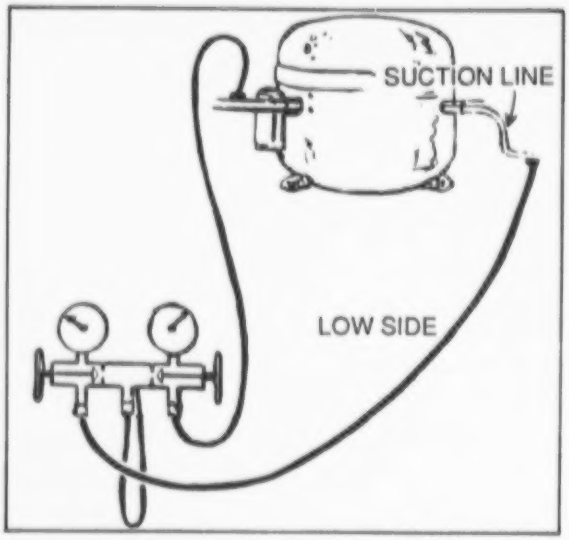
The operating pressures of a system depend upon several variables including temperature drop of the evaporator, temperature difference of supply and return air, wet and dry bulb conditions, and outside ambient conditions. THERE ARE NO SET OPERATING TEMPERATURE AND PRESSURES FOR A REFRIGERATION SYSTEM! The correct operating temperature and pressure can be obtained through proper measurement of the factors listed above.

The following steps of procedure should be performed with supervision by your instructor and require constant monitoring of thermometers, gauges, current draw, and visual inspection of the system until you are certain the system is operating at peak performance.

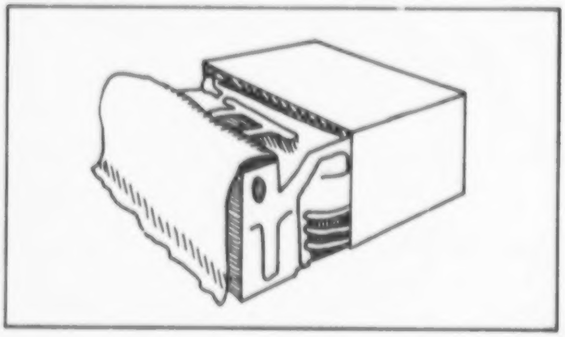
Tools Needed

Clamp-around ammeter
Charging cylinder
Thermometer
Manifold gauges
Newspaper
Refrigerant cylinder

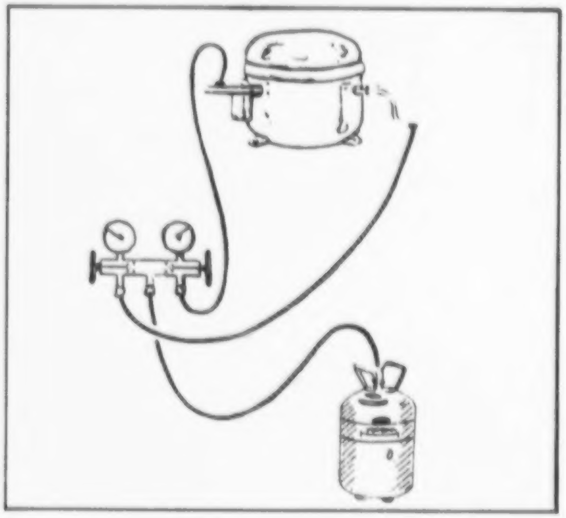
1. Attach the suction and high side hoses of the manifold to the system so they are barely connected and not depressing the valve core.



2. Place the newspaper over the evaporator, completely restricting the air flow.

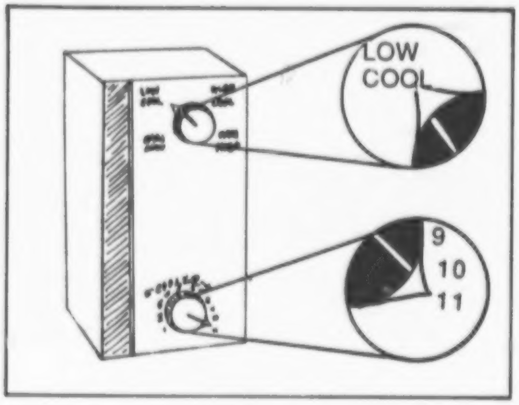


3. Attach the refrigerant cylinder (in upright position) to the center hose of the manifold.



4. Purge the air from the hoses.

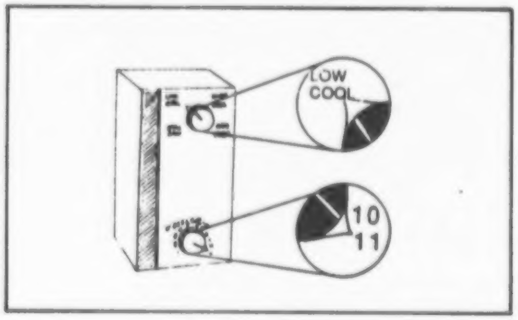
5. Set the thermostat in the coldest position.



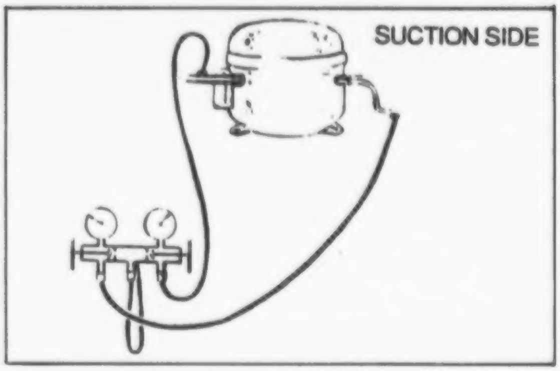
6. Make certain the air filter is clean or removed for charging.

7. Start the system and place on low cool speed.

8. The system has been evacuated Purge lines and then hand tighten both low and high service hoses - the gauges will show a vacuum.

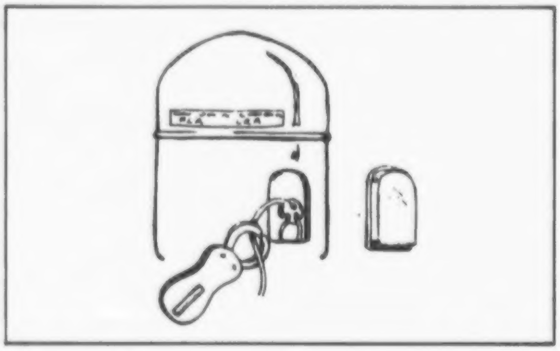


9. Open the suction port of the manifold, allowing refrigerant to enter the suction side of the system.

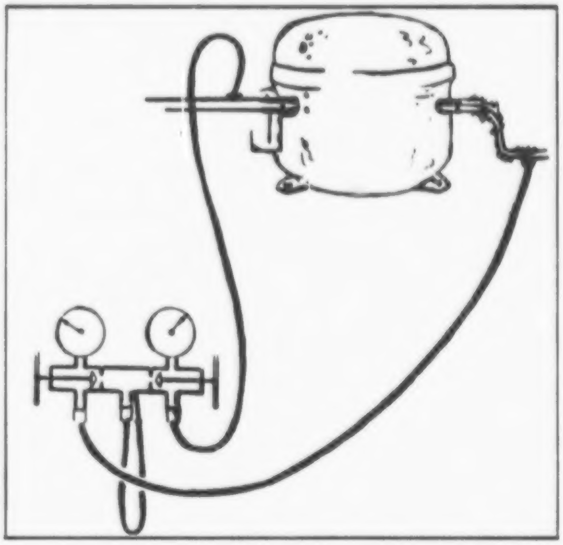


10. Do not open completely! Only allow a small amount of pressure above the operating pressure.

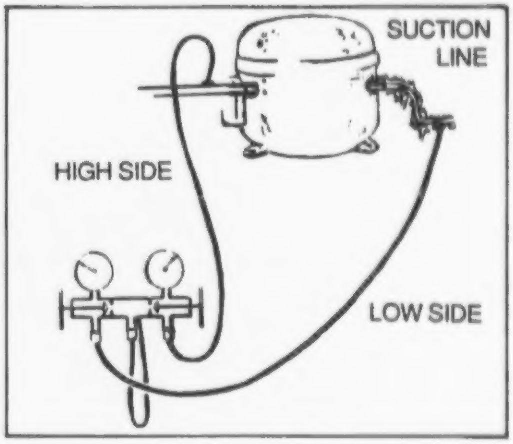
11. Attach the clamp-around ammeter to the common terminal wire of the compressor and monitor the compressor current draw compared to its FLA rating.



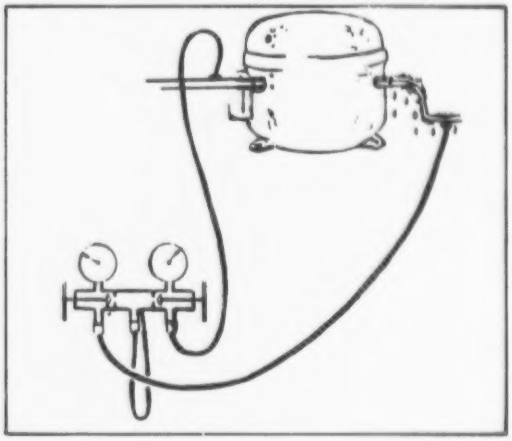
12. With the newspaper restricting the evaporator air flow, frost will start to appear on the evaporator equal to the refrigerant level. When properly charged, the evaporator will have a small amount of frost and the suction will start to have frost form on it. Frost should not be allowed to cover the suction line to the compressor.



13. Monitor the frost level while continuing to charge the system. When frost starts to appear on the suction line, the system is charged, and the newspaper should be removed immediately.



14. The system should continue to operate. Check the evaporator temperature difference, watch for a good "sweat" on the suction line, do exceed FLA current.



15. When confident the system is operating efficiently and properly, remove the hoses and close the system.

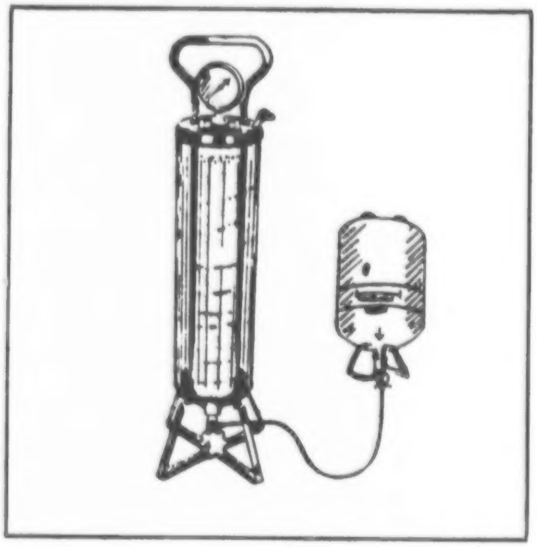
Steps of Procedure for Charging Cylinder (Dial-A-Charge)

1. Look at the system name plate and determine the refrigerant type and amount of charge.

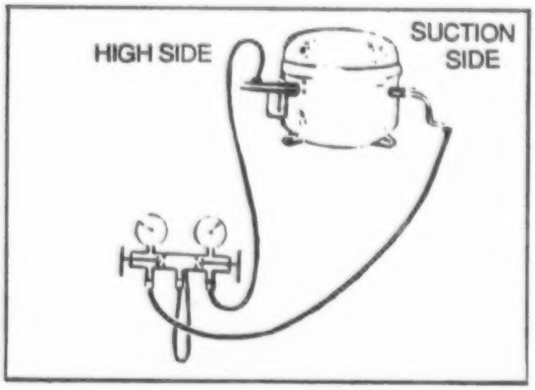
MODEL AH 43212000	**COOL HAND LUKE MANUFACTURING**	
SERVICE # 12398765		
FLA 18	LRA 70	220V AC
1Ø	12,000 BTU	
REFRIGERANT CHARGE 32OZ. - R22		

2. Transfer refrigerant from the refrigerant cylinder into the charging cylinder. (This procedure is described on page 23 of this unit.)

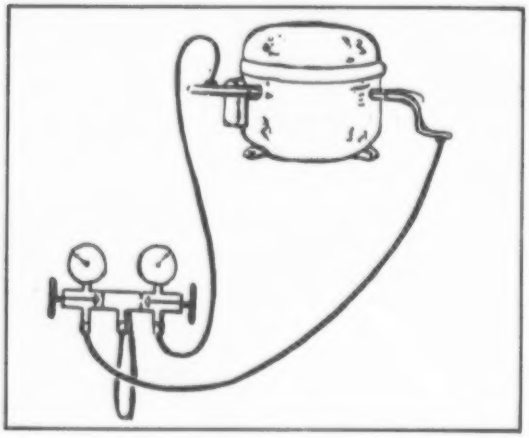
3. The charging cylinder allows you to put the EXACT amount of refrigerant in the system.



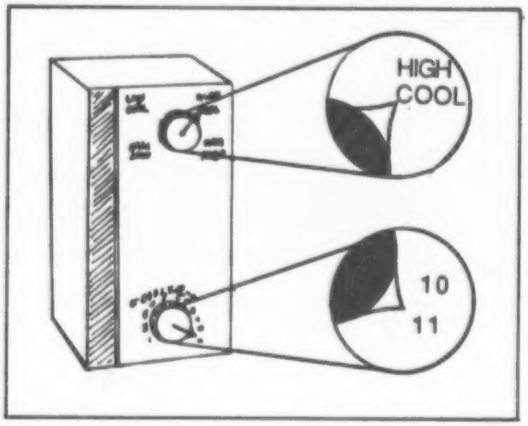
4. Install the manifold gauge hoses to the suction and high side of the system. The hoses should be installed loosely, so as not to depress the valve cores.



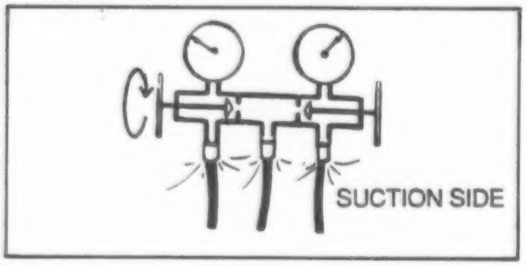
5. Attach the charging cylinder to the center manifold hose. Purge all hoses.



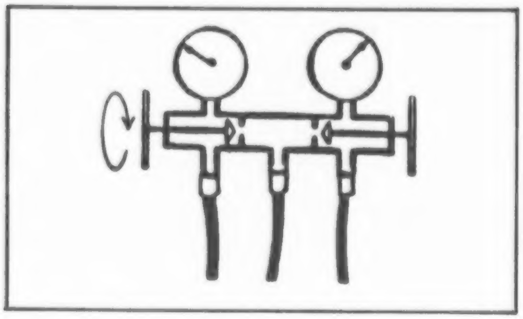
6. Start the system with the thermostat in the coldest position and fan selector on high cool.


HIGH
COOL
10
11

7. Open the suction side service valve and weigh in the measured charge.


SUCTION SIDE

8. When the desired charge has been added, close the suction manifold valve and charging cylinder valve.



9. Close both service valves, and remove the charging manifold. Monitor the system to insure proper operation and to observe the system's high and low side pressures and temperatures.

F. Steps of Procedure for Charging a Central Air Conditioning System

It is more difficult to determine the exact amount of refrigerant to charge a central system than a window unit. The manufacturer does not know the length of lines to connect the evaporator or if the installer followed the correct sizing. Also, the central unit is usually of a larger capacity and requires more refrigerant. Most units should be charged following recommended specifications found in a service manual. This will require the measurement of dry and wet bulb temperatures, as well as other checks.

CAUTION: These steps of procedure follow a well known "ambient plus 30" method that will **NOT** work for all units (particularly high efficiency models).

Tools Needed

Thermometer
Refrigerant wrench
Refrigerant
Charging manifold
Clamp-around ammeter

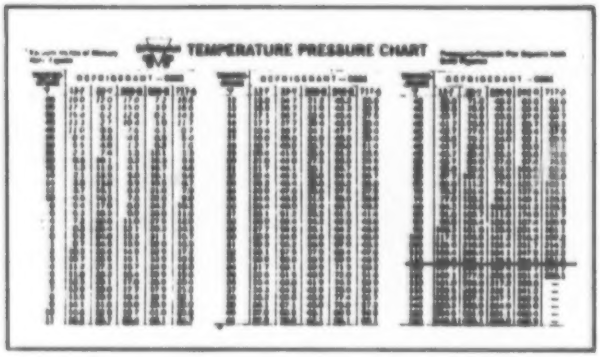
1. Place the thermometer close to the condensing unit in the shade to measure ambient temperature.

2. After the thermometer has stabilized, locate that temperature on the temperature-pressure chart of the high side gauge.

3. Add 30 to the ambient temperature you located on the gauge chart.

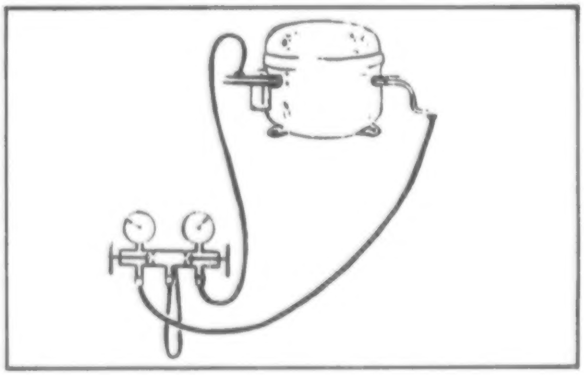
4. Draw a straight line (such as the gauge needle would be) from the ambient temperature plus 30 and determine the desired high side operating pressure.

   Example: The ambient temperature is 85°F and the system uses R-22 refrigerant. 85 plus 30 = 115 and is located on the R-22 temperature gauge scale. The desired pressure is 242.7 pounds per square inch gauge, operating high side.



TEMPERATURE PRESSURE CHART

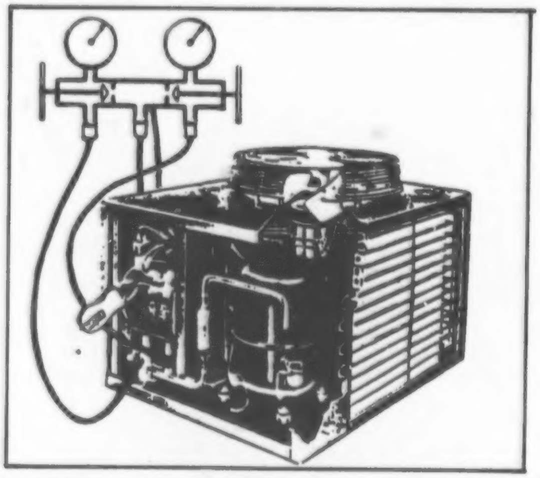
5. Attach the manifold to the system loosely--do not depress valve cores.



6. Attach the refrigerant tank to the center hose.

7. Purge the hoses and tighten all hoses to fittings only finger tight (as you could possibly cut the "O" rings in the hose fittings).

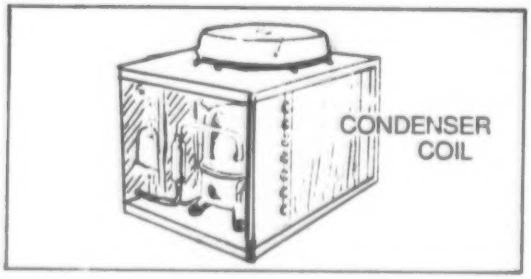
8. Install the clamp-around ammeter to the compressor common terminal wire.



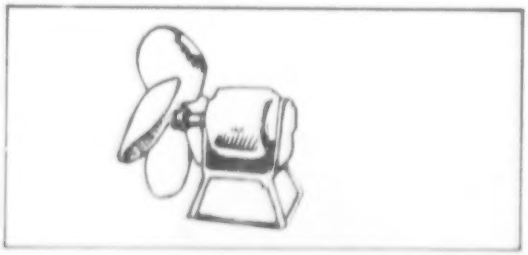
9. Determine the FLA current draw of the compressor from the data plate, if possible.

MODEL AH 43212000	**COOL HAND LUKE MANUFACTURING**	
SERVICE # 12398765		
FLA 18	LRA 70	220V AC
1Ø	12,000 BTU	
REFRIGERANT CHARGE 320Z. - R22		

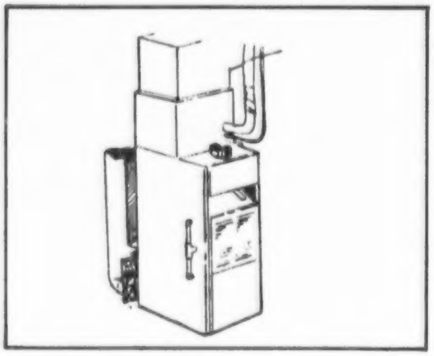
10. Check the condenser coil to make certain it is clean and the fins are not damaged.



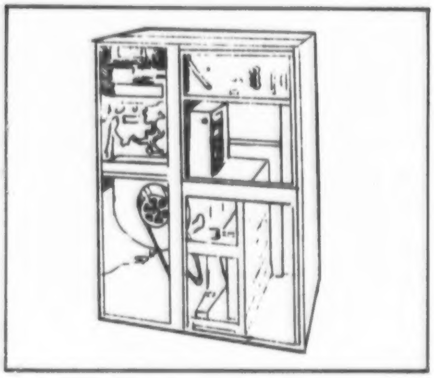
11. Inspect the condenser fan for proper operation.



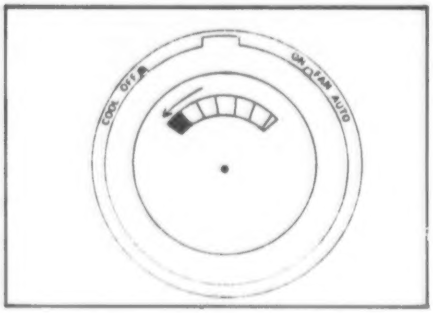
12. Check the evaporator air filter and replace or clean.



13. Check the blower for proper operation.



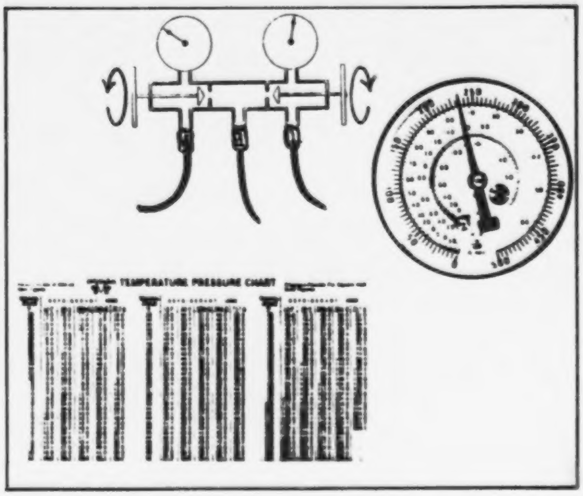
14. Set the wall thermostat on "auto fan," "cool mode," and at the lowest temperature.



15. The condensing unit should now be operating unless it has a low pressure switch. Ask your instructor.

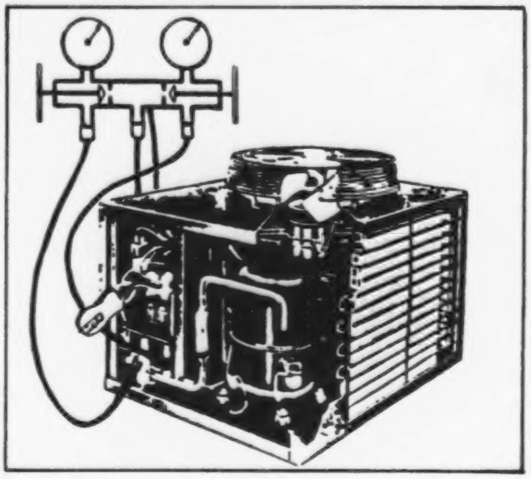
16. Open both service valves.

17. Open the manifold low side valve, allowing refrigerant to enter the system.



18. Continue adding refrigerant until the desired HIGH side pressure has been reached.

19. The system should be charged, but you should continue to monitor the amperage and pressures. Also observe the suction line for a good sweat.



20. Some technicians may argue that this procedure is not very accurate and should not be used. However, this procedure is used by many technicians and is practical if you recognize the limitations and do not have access to service information for the model or brand.

CHARGING UNITS
UNIT REVIEW

Directions: For each of the following questions, circle the correct answer.

1. Air that gets into a system contains moisture and non-condensable gases.
   True   False

2. To blow air out of a hose or line with refrigerant is called
   a. charging   c. evacuation
   b. purging   d. vacuuming

3. To draw air out of a hose or line with a vacuum pump is called
   a. charging   c. evacuation
   b. purging   d. vacuuming

4. To put refrigerant into a system is called
   a. charging   c. evacuation
   b. purging   d. vacuuming

5. On the gauge manifold set, the red hose is connected to the
   a. low side connection   d. all of the above
   b. center connection   e. none of the above
   c. high side connection

6. Before using a vacuum pump, you should
   a. charge the lines with refrigerant
   b. purge the lines with refrigerant
   c. change the oil
   d. check the oil level

7. After using a vacuum pump, you should
   a. charge the lines with refrigerant
   b. purge the lines with refrigerant
   c. change the oil
   d. check the oil level

8. When evacuating a system, the high side manifold valve is opened before the low side manifold valve.
   True False

9. When charging liquid refrigerant into the system, it is charged into the low side access valve.
   True False

10. Which type of eye protection should be used when working with refrigerant?
    a. shop safety glasses
    b. chemical safety goggles
    c. welding safety goggles
    d. sun glasses

CHARGING UNITS

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Evacuate a sealed refrigeration system using the triple evacuate method.			
2. Charge a refrigeration system with an exact amount of refrigerant.			
3. Charge a window air conditioner.			
4. Charge a central air conditioner.			

Satisfactory - Should Move On ☐

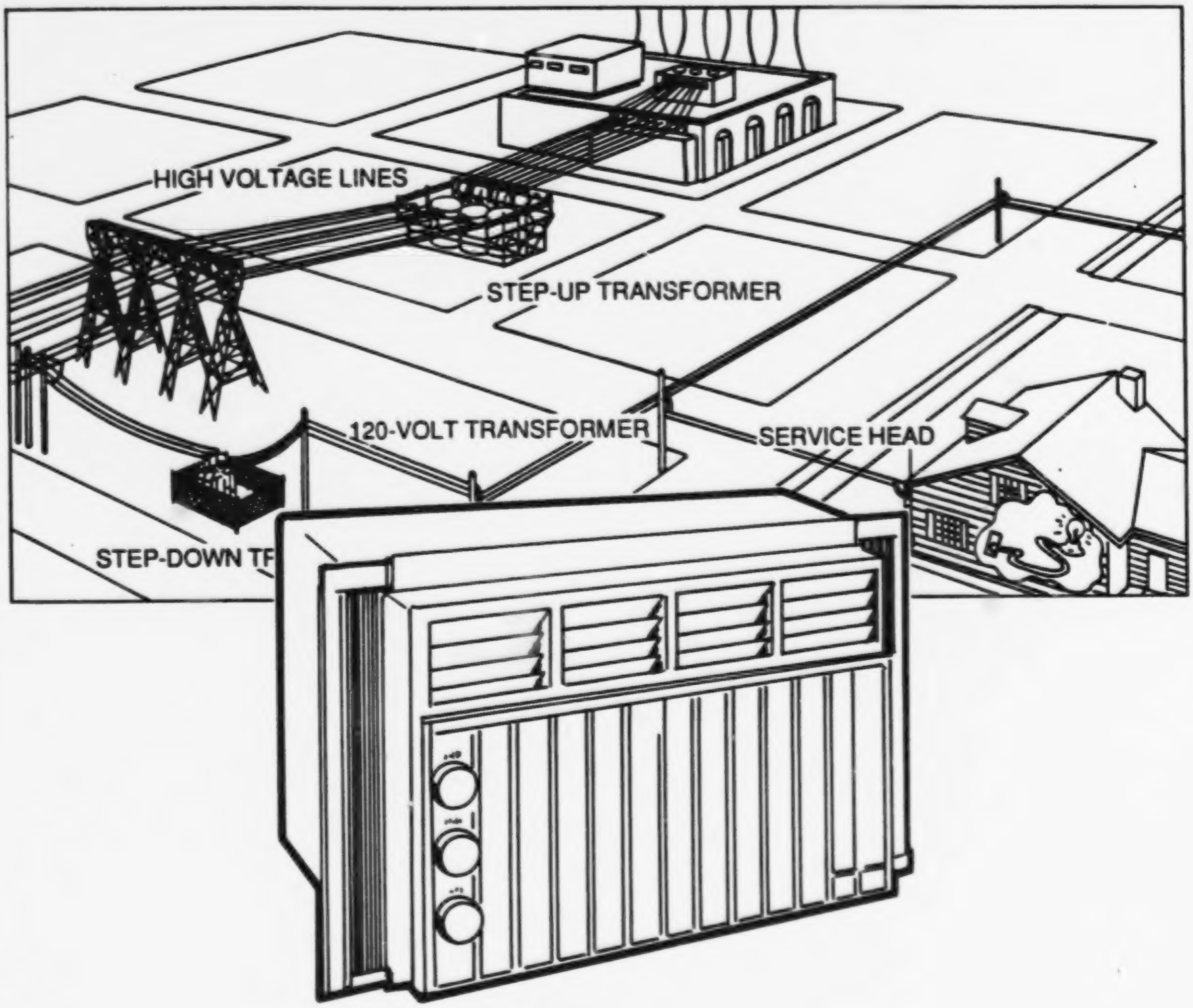
Repeat This Unit ☐

_________________________ Student's Signature/Date

_________________________ Instructor's Signature/Date

90-7040-S

SUPPLEMENTARY UNITS FOR AIR CONDITIONING AND REFRIGERATION


HIGH VOLTAGE LINES
STEP-UP TRANSFORMER
120-VOLT TRANSFORMER
SERVICE HEAD
STEP-DOWN TF

Unit 11

Commercial Refrigeration Units

Preventive Maintenance

PRODUCED BY
THE INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA

FUNDED BY
DEPARTMENT OF ELEMENTARY AND SECONDARY EDUCATION • JEFFERSON CITY, MISSOURI

COMMERCIAL REFRIGERATION UNITS-- PREVENTIVE MAINTENANCE

INTRODUCTION

Preventive maintenance consists mainly of cleaning and inspecting equipment to find and correct small problems before they become big problems that must be fixed by corrective maintenance. A good system of preventive maintenance can pay for itself by reducing operating costs and saving repair costs. This unit will cover common preventive maintenance procedures. Although the tasks are simple to do, they are very important and can add years to equipment life.

NOTE: THIS IS INTENDED TO BE THE LAST UNIT OF A SERIES. THIS UNIT SHOULD NOT BE STUDIED UNTIL ALL OTHER UNITS OF THIS SERIES HAVE BEEN COMPLETED! THE STUDENT MUST HAVE AN UNDERSTANDING OF THE INFORMATION PRESENTED IN THE OTHER UNITS TO COMPLETE THIS UNIT SUCCESSFULLY.

UNIT OBJECTIVE

After completing this unit, you should be able to conduct routine preventive maintenance on commercial refrigeration units.

SPECIFIC OBJECTIVES

After completing this unit, you should be able to:

1. Clean condensers and motors.
2. Check fan blades and belts.
3. Check electrical connections.
4. Check for refrigeration system leaks.
5. Use a preventive maintenance checkoff list.

Check the Statement that Fits You Best

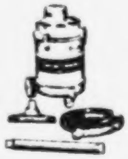
☐ **I can do these tasks and want to go through the Performance Checklist.**

SEE YOUR INSTRUCTOR

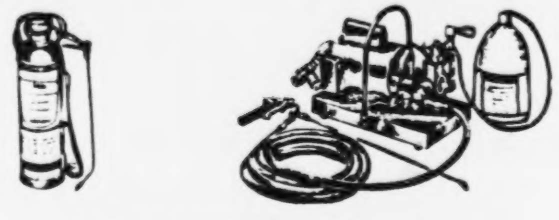
☐ **I want to study the information in this unit before I do the Performance Checklist.**

TURN PAGE AND BEGIN

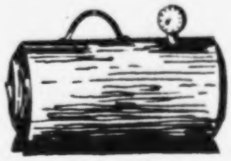
A. Equipment and Supplies



SHOP VACUUM

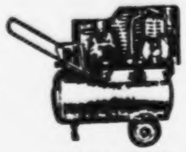


POWER OR HAND SPRAYER

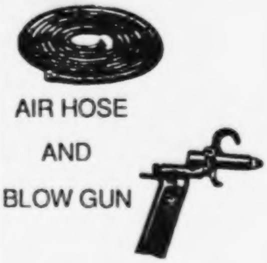


PORTABLE COMPRESSED AIR TANK

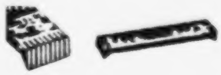
OR



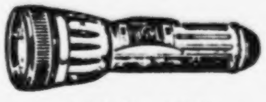
PORTABLE AIR COMPRESSOR



AIR HOSE AND BLOW GUN

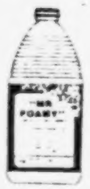


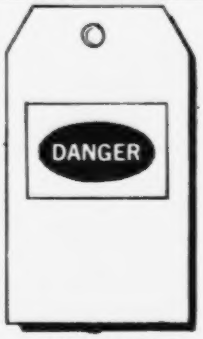
FIN COMB



FLASHLIGHT

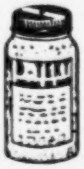
COIL CLEANING LIQUID

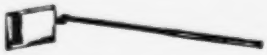




DANGER TAG

LIQUID LEAK DETECTOR

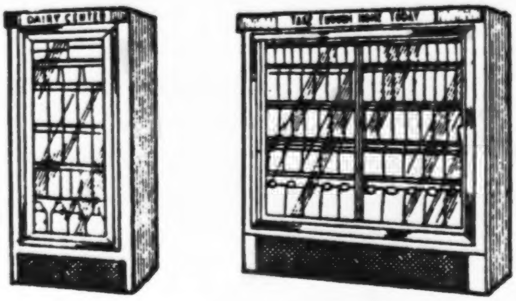




INSPECTION MIRROR

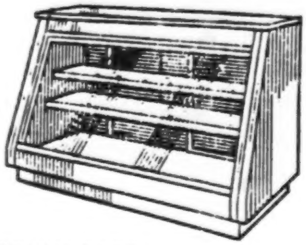
B. Types of Commercial Refrigeration Units

1. Many of the commercial refrigeration units used today are very similar to the domestic refrigerators you studied in an earlier unit.



DISPLAY MERCHANDISERS

2. The commercial refrigeration unit may be self-contained and have its own evaporator, compressor, condenser metering device and condenser fan.



DISPLAY CASE

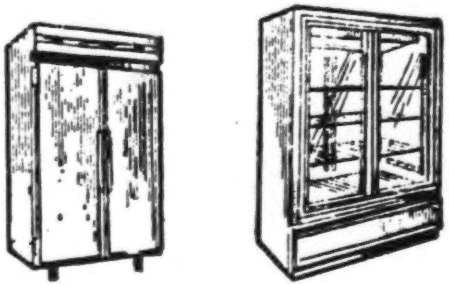
This type of refrigeration unit includes:

a. Display merchandise

b. Full vision display cases

c. Glass door and solid door reach-in coolers and freezers

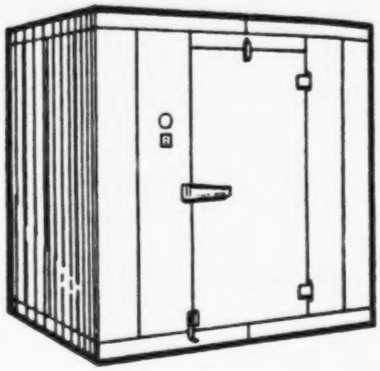
REACH-IN REFRIGERATORS AND FREEZERS



SOLID DOOR

GLASS DOOR

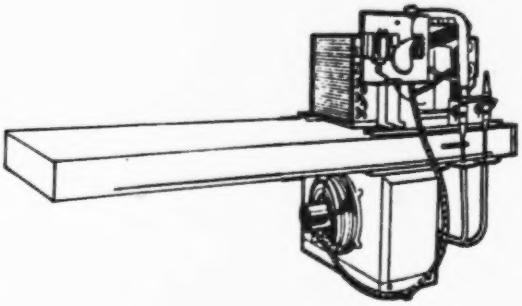
3. This is a walk-in freezer. It is actually a small cold storage room. This type of freezer may have a top-mounted package refrigeration system or a remote condensing unit.



WALK-IN FREEZERS/COOLERS

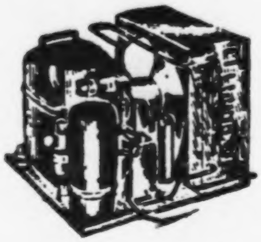
4. A top-mounted package refrigeration unit used on a walk-in cooler or freezer is shown here.

   NOTE: The compressor and condenser sit on the roof of the cooler or freezer. The evaporator hangs below it, suspended from the ceiling inside the refrigerated space.



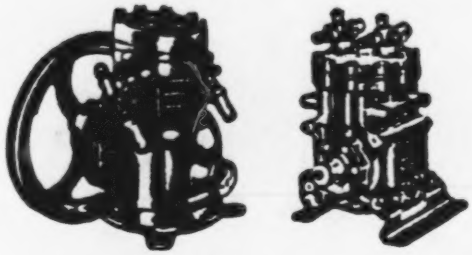
CONDENSING UNIT
(CONDENSER AND COMPRESSOR)

5. Refrigerated display cases and walk-ins may also be used with split systems that have remote condensing units.

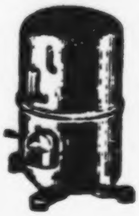


CONDENSING UNITS

6. The remote condensing unit contains the compressor, condenser, condenser fan, filter/dryer, sight glass, and receiver. Remote condensing units may be installed inside machinery rooms or located outside the building. The compressor of the remote condensing unit may be any of the following types: (a) open, (b) hermetic, or (c) semi-hermetic.

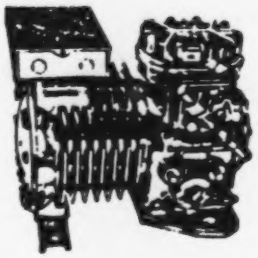


OPEN TYPE COMPRESSORS

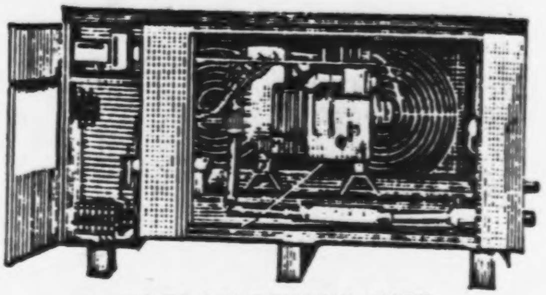


HERMATIC COMPRESSOR

SEMI-HERMATIC
COMPRESSOR



This illustration shows a condensing unit in an outdoor enclosure with the cover removed and service door open.



OUTDOOR CONDENSING UNITS

C. Working Safely

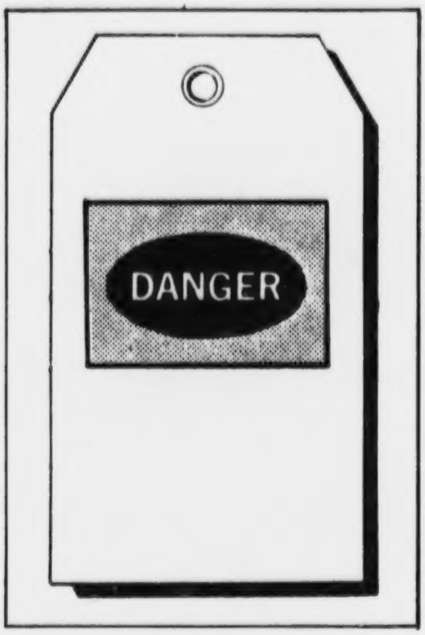
CAUTION: COMMERCIAL REFRIGERATION EQUIPMENT IS CONTROLLED BY PRESSURE AND TEMPERATURE SWITCHES. IT WILL START UP WITHOUT WARNING. DO NOT GET TOO CLOSE TO MOVING PARTS WHEN INSPECTING EQUIPMENT. TURN POWER OFF BEFORE WORKING ON EQUIPMENT.

1. **BEFORE WORKING ON EQUIPMENT, TURN OFF THE POWER AT THE SUPPLY PANEL**

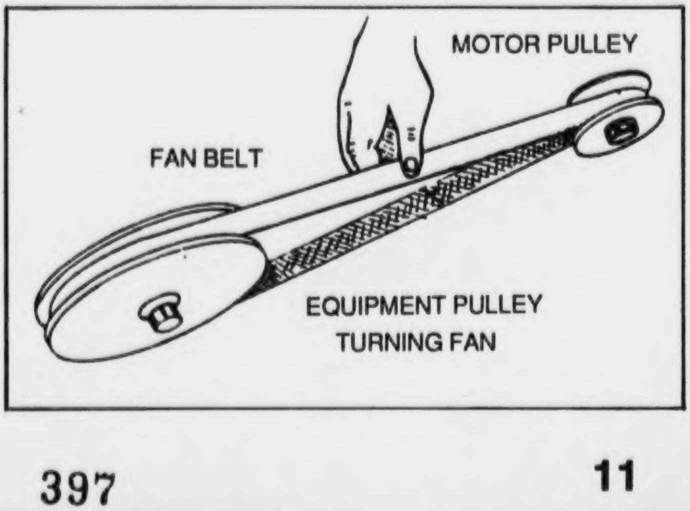
AND

PUT A DANGER TAG ON THE POWER SUPPLY CIRCUIT BREAKER OR FUSES.

(NOTE: Tie the danger tag to the power supply AFTER power has been turned off.)

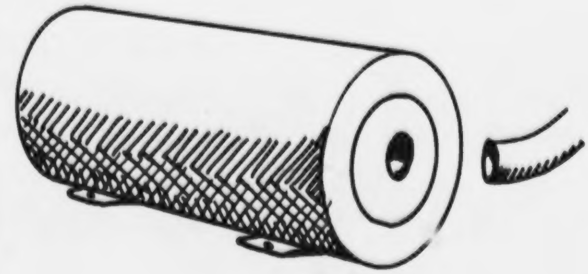


2. **DO NOT** touch fan blades, belts, or other moving parts until after power has been turned off.



D. Cleaning Condensers and Motors

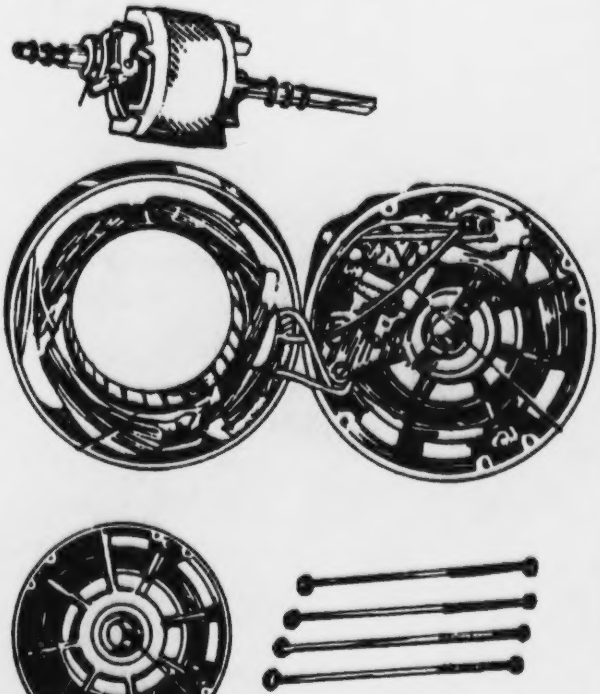
1. Dust and dirt should be cleaned from the air vents in the motor end bells. Use the shop vacuum cleaner to remove dust and dirt. Do not use compressed air, as it will only blow the dirt deeper into the motor. Use a damp rag to clean any fan blades.



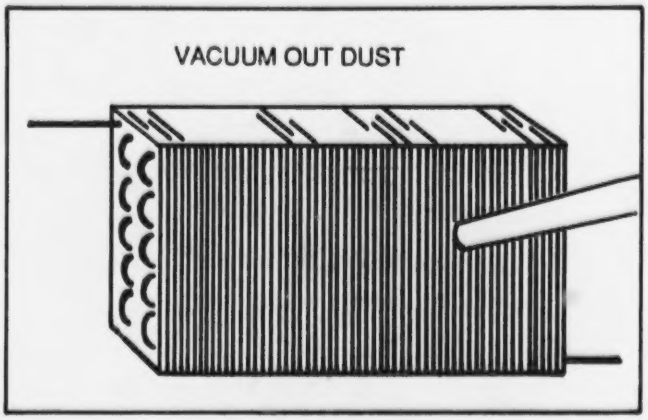
VACUUM CLEANER

2. Use a flashlight and an inspection mirror to look into the air vents. If they are very dirty, the motor should be taken apart and completely cleaned (as explained in an earlier unit).

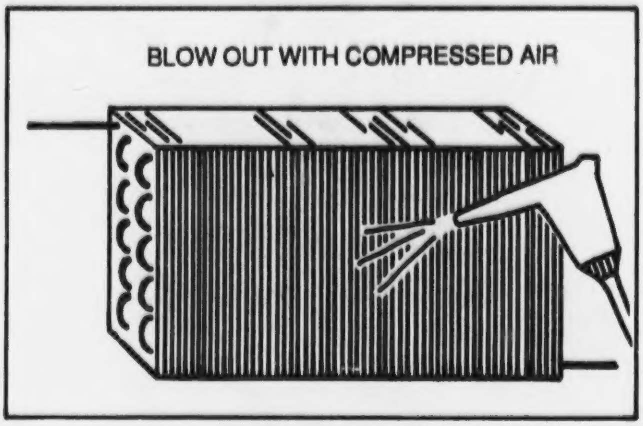
   This motor has been taken apart for complete cleaning.



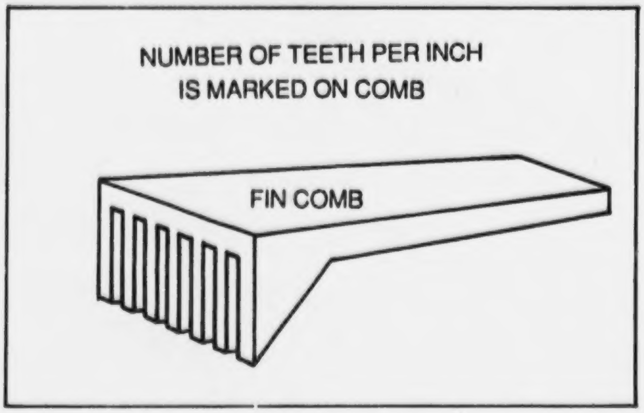
3. Cleaning the condenser is the most important part of any preventive maintenance job.


VACUUM OUT DUST

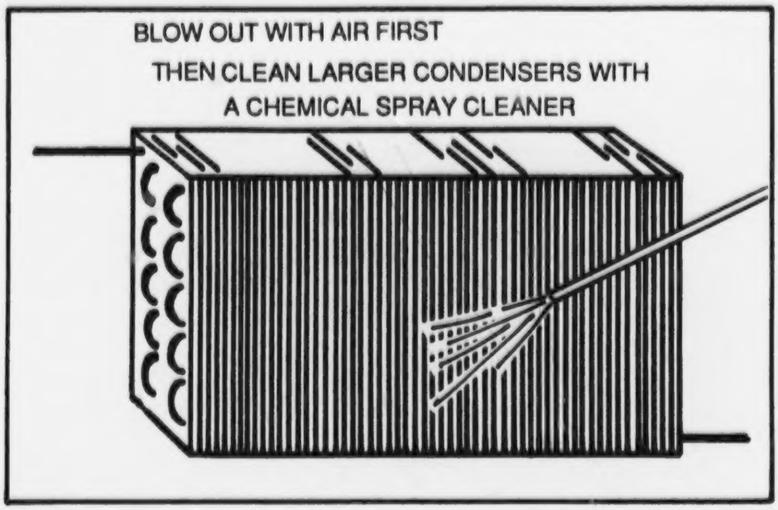
4. Small condensers on some units can be cleaned using a vacuum cleaner. Be sure to clean all dust and dirt in the area around the condenser. Then vacuum the area of the fins. Finish the job by blowing out the space between the fins. Use compressed air, if it is available.


BLOW OUT WITH COMPRESSED AIR

5. If any condenser fins are mashed down, use a fin comb to straighten them. Be sure to use a fin comb tool that has the same number of teeth per inch as the number of fins per inch on the condenser.

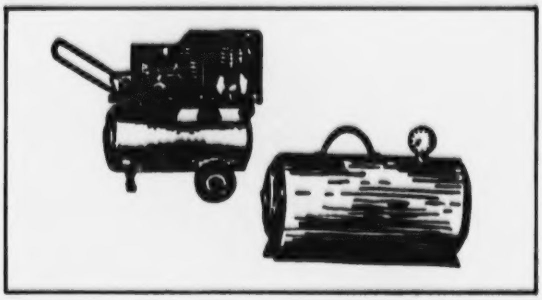

NUMBER OF TEETH PER INCH
IS MARKED ON COMB
FIN COMB

6. Large condensers are cleaned by blowing compressed air through the fins to remove all loose dirt.

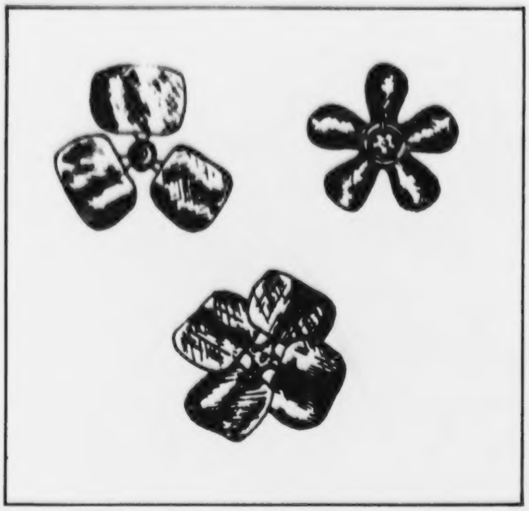

BLOW OUT WITH AIR FIRST
THEN CLEAN LARGER CONDENSERS WITH A CHEMICAL SPRAY CLEANER

7. Spray a refrigeration condenser coil cleaner on the fins and coils. Let set for 15 minutes. Then rinse and blow dry.

8. Your source of compressed air can be a portable air compressor or a portable air storage tank.

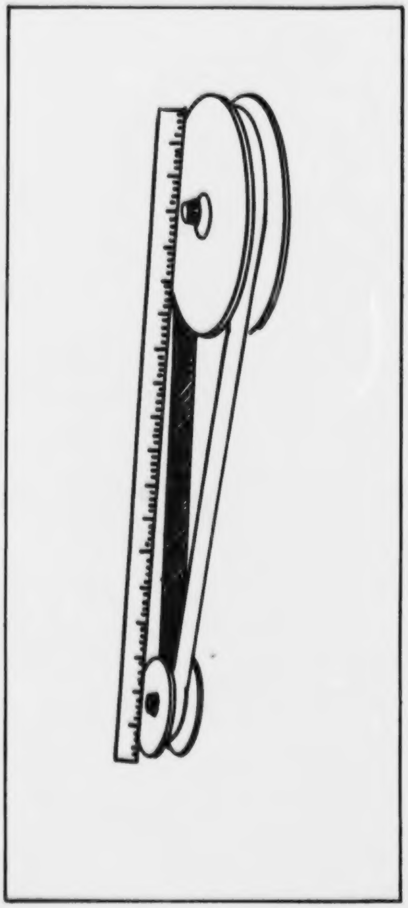


E. Checking Fan Blades and Belts



1. Check fan blades to be sure that they are not:
   Bent,
   Dirty,
   Loose on shaft,
   Cracked from fatigue, or
   Rubbing or hitting anything.

2. Any drive belts should be inspected to be sure they are not cracked or frayed.

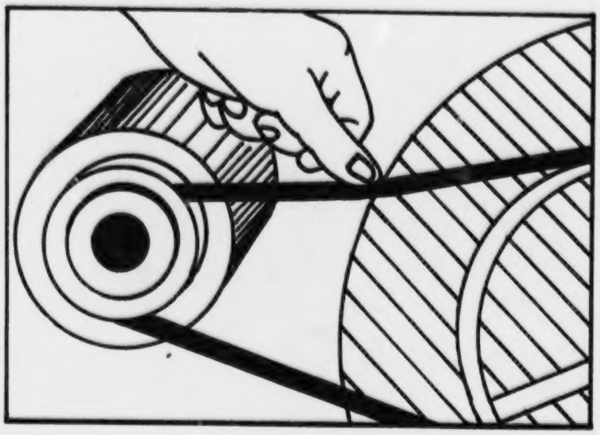


3. Pulleys should line up evenly. To check the line-up of pulleys, use a straightedge.

4. Drive belts must not be loose, and they must not be too tight.

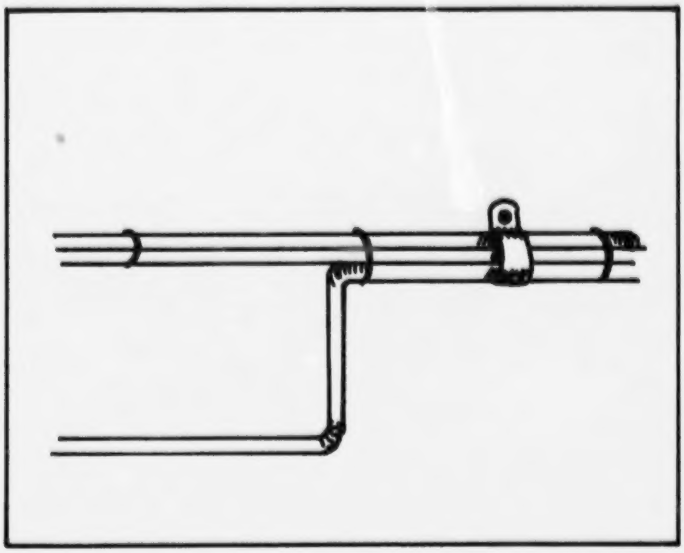
   If you can press down on the center of the belt with your thumb and make it move one inch, but no more, then the belt is at the right tightness.

   NOTE: The best method of checking belt tightness is to attach an ammeter to the motor lead and tighten the belt until the meter registers the FLA of the motor.



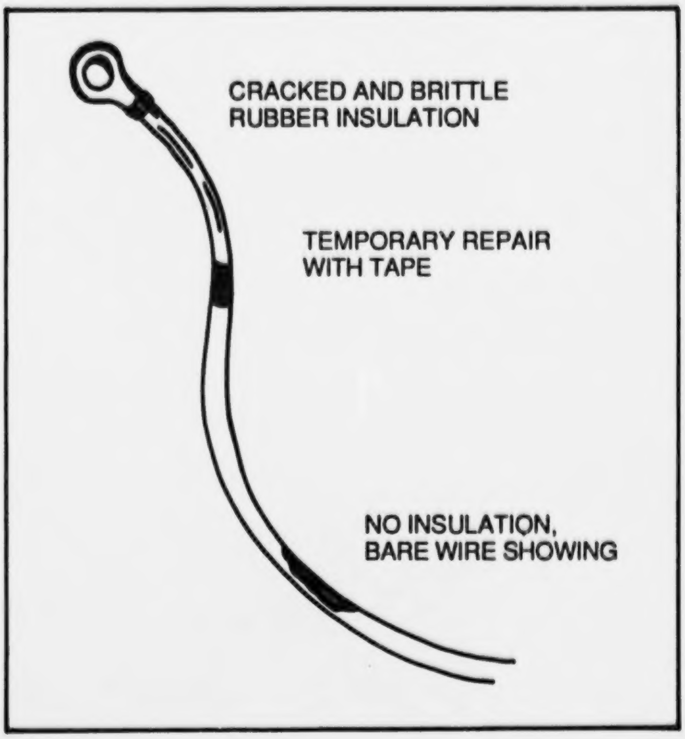
F. Check Electrical Connections and Wires

1. Electrical wires should be supported or banded to other electrical wires. The wiring should look neat, as shown in this illustration (note that the wire is supported by clamps).



2. Electrical wires should be in good condition. Insulation should be free from cracks and not frayed. The rubber insulation must not be brittle. There must be no missing insulation.

   If the insulation on the wire is poor, the wire should be replaced.

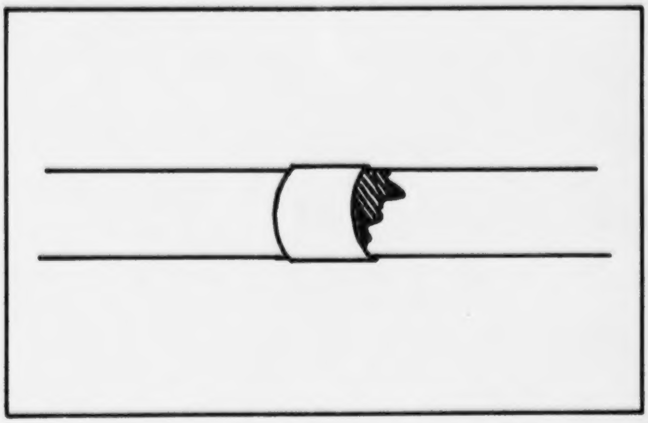

CRACKED AND BRITTLE RUBBER INSULATION
TEMPORARY REPAIR WITH TAPE
NO INSULATION, BARE WIRE SHOWING

3. An electrical connection must be tight. If you can move or jiggle it, it is too loose.

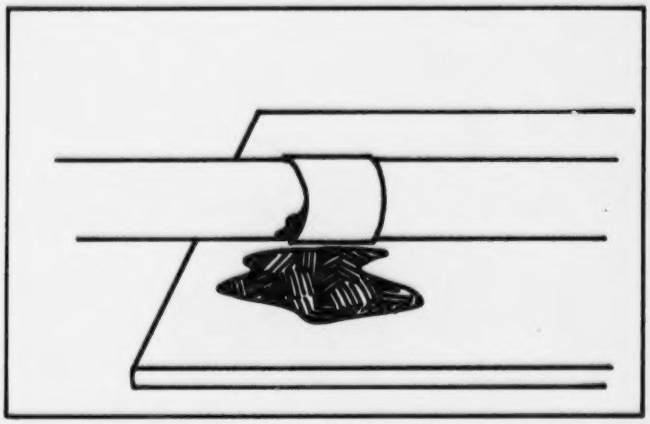
   Check to see if any electrical wire or component looks or smells burnt or charred.

G. Inspect Refrigeration System for Signs of Leaks

1. Oil travels through the refrigeration system with the refrigerant. If refrigerant is leaking from the system, it is very likely that oil is also leaking from the system at the same place.



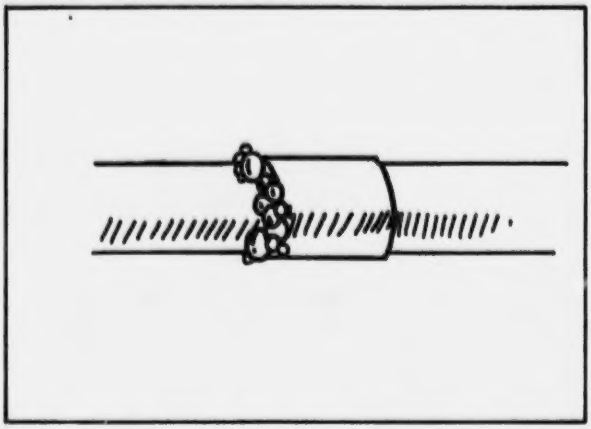
2. An oil film or stain on or under a tube is a good indication of a leak.



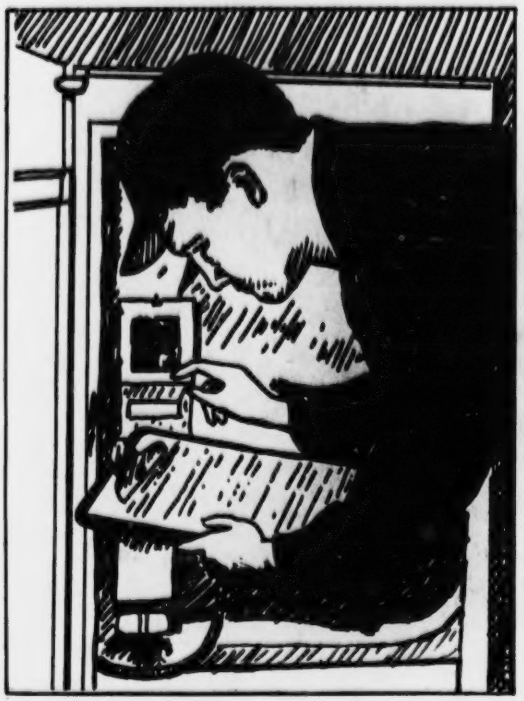
3. Look for signs of leaks at joints, connections, bends, and any place a tube is rubbing against another object.

   (Tubes should not be allowed to rub against anything.)

4. Liquid bubble leak detector can be used to find out if a leak is present. Bubbles will form at a leak when a liquid leak detector is used. If a leak is found, it must be repaired.



5. To help you remember all the things that must be checked and looked at when doing a preventive maintenance inspection, it will be helpful to use a check-off sheet.



6. After preventive maintenance has been completed, turn power back on and check system operation.

DO ACTIVITY SHEETS 1 and 2.

DO SKILL SHEET 1

COMMERCIAL REFRIGERATION UNITS--PREVENTIVE MAINTENANCE

ACTIVITY SHEET 1

Directions: Make your own check-off sheet. To do this, make a list of everything you would check for when doing preventive maintenance on equipment.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________

14. ______________________________

15. ______________________________

List containing at least 10 items = Fair
List containing 15 items = Good
List containing more than 15 items = Very Good

COMMERCIAL REFRIGERATION UNITS--PREVENTIVE MAINTENANCE

ACTIVITY SHEET 2

Directions:

1. Using the check-off list on the next page, explain to your instructor how you would conduct an inspection of a commercial refrigeration unit.

2. Conduct an inspection of a commercial refrigeration unit as directed by your instructor.

CHECK SHEET

REFRIGERATION SYSTEMS MAINTENANCE

NAME OF CUSTOMER ______________________

UNIT NUMBER OR NAME ______________________

NAME OF SERVICEMAN ______________ **DATE** ________

	NOT SATISFACTORY	SATISFACTORY	NOT SATISFACTORY	SATISFACTORY
GENERAL INSPECTION				
1. Check for signs of leaks (oil spots, stains).				
2. Check suction line (cool but not frosted or sweating).				
3. Check liquid line (close to ambient temperature).				
4. Check that lines are not rubbing other lines or components.				
5. Check oil level sight glass on compressor (visible level).				
6. Check refrigerant liquid line sight glass (no bubbles).				
7. Check moisture indicator (look for color change).				
8. Check for cleanliness:				
a. Air inlet and outlet vents (free from dust).				
b. Air inlet filters (clean or replace).				
9. Check all lines (not pinched, no dents or restrictions).				
10. All nuts, bolts, screws, caps, and covers in place.				
CONDENSER				
1. Straighten fins if needed.				
2. Check that air flow is not blocked by foreign matter.				
3. Clean condenser (air cooled condenser only).				
4. Water cooled condenser:				
a. No drain water discharge when compressor is not running (stopped for 5 minutes or more).				
b. Warm drain water at discharge when compressor is running.				
ELECTRICAL				
1. Check fuses.				
2. Check for loose connections.				
3. Check for signs of over-heated components (charred, smell, discolored).				
4. Check for frayed or brittle insulation on wires.				
5. Electrical lights working (if installed).				

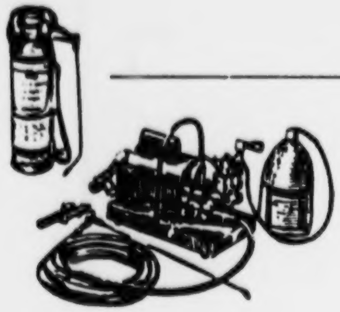
	NOT SATISFACTORY	SATISFACTORY	NOT SATISFACTORY	SATISFACTORY
MOTORS, BELTS AND FANS				
1. Check and lubricate motors.				
2. Check belt for condition, tension, and alignment.				
3. Check fans.				
PRESSURE AND TEMPERATURE				
1. High side pressure ______________ PSI.				
2. Low side pressure ______________ PSI.				
3. Ambient temperature ______________ °F.				
4. Evaporator temperature _____________ °F.				
5. Refrigerated space temperature _________ °F.				

COMMENTS:

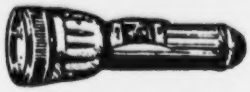
SKILL SHEET 1

Directions: In the blank beside each picture below, write the name of the item pictured. The pictured items are all needed to perform preventive maintenance on a unit.

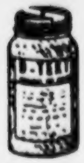
1. ____________________



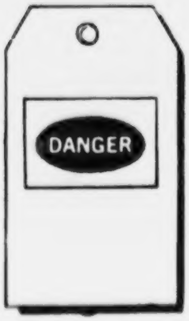
2. ____________________



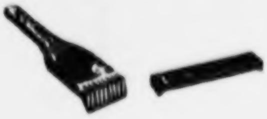
3. ____________________



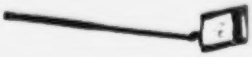
4. ____________________



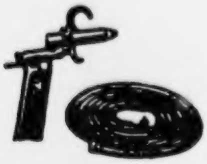
5. ____________________



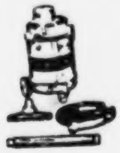
6. ____________________



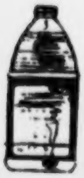
7. ____________________



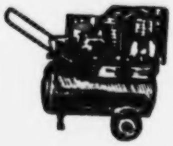
8. ____________________



9. ____________________



10. ____________________



COMMERCIAL REFRIGERATION UNITS--PREVENTIVE MAINTENANCE

UNIT REVIEW

1. Major repair work is called "preventive maintenance."
   True or False

2. Electrical power must be turned off for what type of work on the system?
   a) Electrical maintenance.
   b) Refrigeration system maintenance.
   c) Preventive maintenance.
   d) All of the above.
   e) None of the above.

3. Many commercial refrigeration units are very similar to household refrigerators and freezers.
   True or False

4. The condenser is located in the:
   a) Condensing unit.
   b) Evaporator.
   c) Chiller.
   d) All of the above.
   e) None of the above.

5. The condensing unit can be located outside the building.
   True or False

6. To completely clean a motor that is very dirty, you may have to take it apart.
   True or False

7. Air vents on motors should be blown out with compressed air.
True or False

8. Condensers are cleaned by washing with hot, soapy water.
True or False

9. A belt is at the right tightness when pressing the center of the belt with your thumb:
   - a) will not move the belt.
   - b) will move the belt one inch.
   - c) will move the belt two inches.
   - d) none of the above.

10. Electrical wires with poor insulation should be repaired with electrical tape.
True or False

COMMERCIAL REFRIGERATION UNITS-- PREVENTIVE MAINTENANCE

PERFORMANCE CHECKLIST

Student ______________________________ has successfully performed the following steps of procedure.

Procedure	Yes	No	Comments
1. Clean condensers and motors.			
2. Check fan blades and belts.			
3. Check electrical connections.			
4. Check for refrigeration system leaks.			
5. Use a preventive maintenance checkoff list.			

Satisfactory - Should Move On ☐

Repeat This Unit ☐

_________________________ Student's Signature/Date

_________________________ Instructor's Signature/Date